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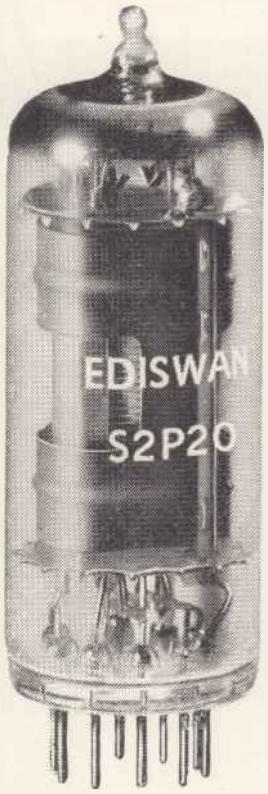

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$V_{g2\,(max)}$	Screen Voltage, maximum (volts)	150
g_m	Mutual Conductance (mA/V)	4.3
$P_{a\,(max)}$	Anode Dissipation, maximum (watts)	5.0

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Wireless World

ELECTRONICS, RADIO, TELEVISION

AUGUST 1960

Managing Editor:

HUGH S. POCOCK, M.I.E.E.

Editor:

F. L. DEVEREUX, B.Sc.

Assistant Editor:

H. W. BARNARD

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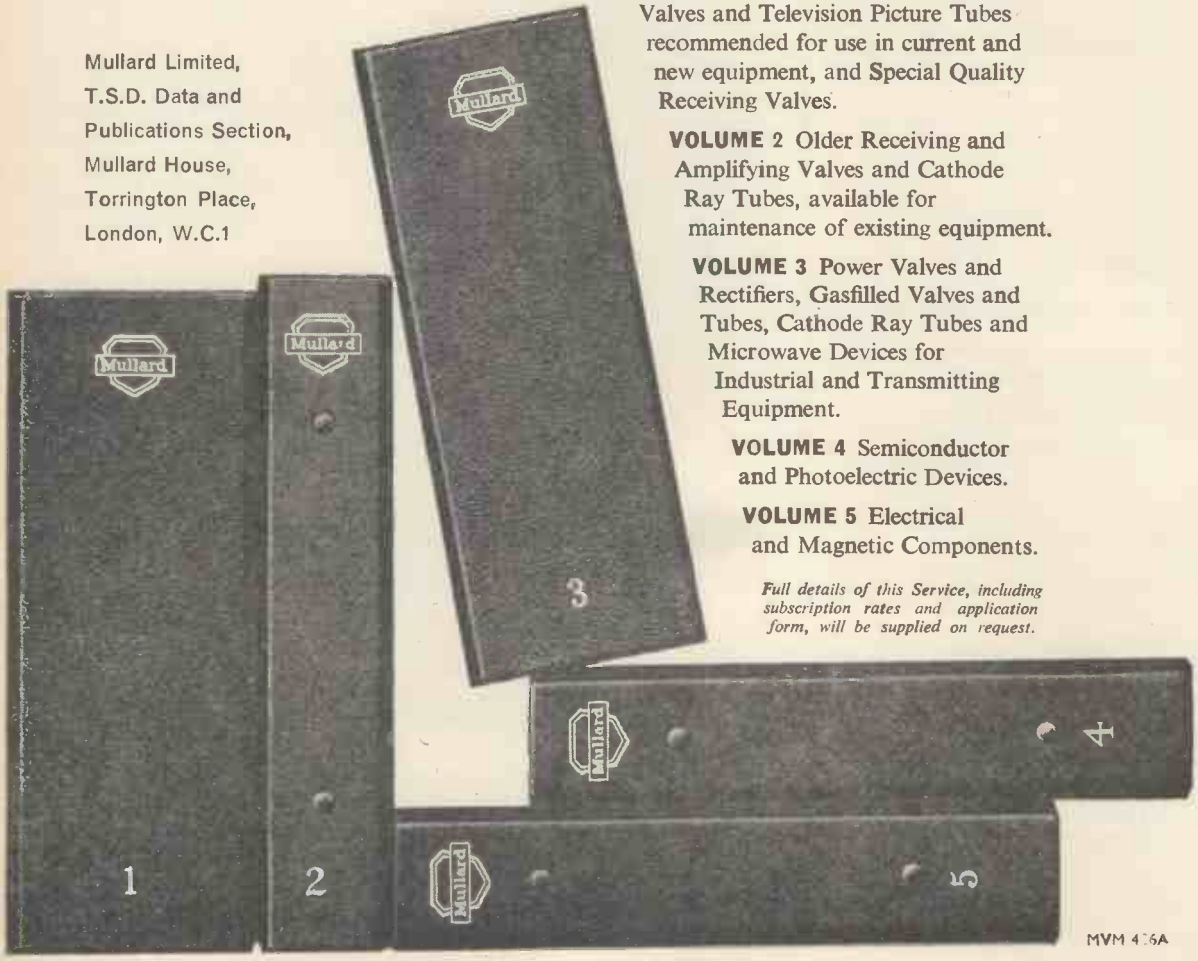

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AUGUST 1960
Vol. 66 No. 8

Wireless World

Reliability

THE emergence of electronics from the physics laboratory and its acceptance as an essential part of industrial and indeed of everyday life was amply confirmed by the scale of the recent I.E.A. Exhibition at Olympia and by the range of topics and lively discussion at the concurrent E.F.F.I. conference under the title "User Experience of Electronics in Industry."

The versatility and flexibility of electronics have through long familiarity ceased to be a source of wonder. It was no surprise to find at this conference papers on stock control and insurance computation followed by machine control and heat treatment, or a lecture on process control in petroleum refining between discussion of biscuit-making and steel production; but we hope that the many young electronics engineers in the audience were as impressed as we were by the revelation of the conditions under which some of their pet designs are expected to work—the high temperature and humidity of paper works, where in one instance an air-conditioned room had to be built to house the control equipment, and the radiant heat from steel strip which has called for the use of water cooling for phototransistors in equipment designed for the control of strip width by optical methods. Even in the equable atmosphere of an insurance office there may be hidden environmental hazards in the form of electrical interference. One case was reported of the mutilation of the contents of a computer store by spurious pulses arising from a radio-frequency ripple on the neutral line of the power supply.

The possible consequences of even the slightest malfunction of electronic equipment are often frightening. If a width gauge is faulty a whole coil length of steel strip may be considered as scrap and it would then be necessary to roll 100 coils accurately to make up the loss. In the three-dimensional profile milling of steel wing sections for high speed aircraft a 3in-thick billet of anything up to 40ft in length may have to be reduced to a skin thickness of 0.064in, and here again scrap can be very expensive. Petroleum refineries, where electronic controls in conjunction with digital computers are tending to take the place of analogue and pneumatic-hydraulic control, are expected to work continuously throughout the "on stream" period of 9 to 18 months with not more than 2% shut-down time for instrument maintenance.

Not only in industry, but also in the civil and military services the question of reliability is never far from the thoughts of those who must put their trust in electronic devices. Problems of maintenance have been thrown into relief by the phenomenal reliability of the gas turbine engine which has greatly reduced the turn-round time for short-haul airline services. The demand is now for radio aids which will go for 3,000 flying hours between major overhauls. These and other matters such as the storage reliability of guided weapons were discussed in detail at the Symposium on Electronic Equipment Reliability organized by the Institution of Electrical Engineers. This was concerned with field experience and methods of assessing and predicting reliability and showed that the best way of coming to terms with the problem is to accept the fact of unreliability, to circumscribe it by routine maintenance or built-in self-checking facilities and by statistical analysis of case histories to trace the root causes of failure. It is interesting to note that routine testing can itself be the cause of unreliability. A case reported to the Symposium showed how failure of diodes in a large computer was traced to momentary short circuits when applying test probes. Insulation of adjacent conductors resulted in a reduction of the failure rate from as much as 4.4% to 0.03% per 1,000 hours.

The study and improvement of reliability is now a technology in its own right with its own specialized vocabulary; it may even be said in some respects to have attained the status of a science. Looking to the future we can safely build on the reliability of the electron itself, but there is still much to be learned of its behaviour in association with other elementary particles. In short, solid state physics and the properties of materials open a wide field for investigations into the long-term stability of the basic ingredients of electronic circuits. Meanwhile there is plenty of scope for simplification of some of the electronic "technicians rackets" we see employed for simple menial tasks; other things being equal, the chances of failure must increase with complexity and the number of elements involved. Ultimately, the best methods of achieving reliability are learnt from experience, but, as has so often been said, the fees are high.

Floreat Regalis Societas

ON the occasion of the tercentenary of the Royal Society we tender our respects and felicitations and wish the Society continued strength and wisdom in the future in fulfilling its functions as a touchstone of truth and a symbol of goodwill in the international relations of science.

Although the interests of the Society are wide (scientific disciplines have increased exponentially in recent years) it has not neglected to support research which is fundamental to radio astronomy and communications. In particular we have in mind the work of the Halley Bay station organized by the Royal Society during the International Geophysical Year.

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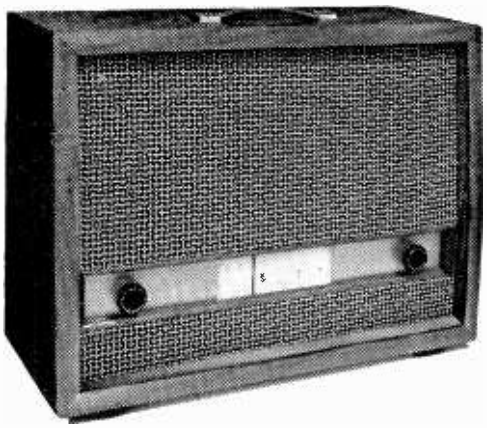


In the three parts of this article a v.h.f./f.m. receiver of straightforward design is described: transistors of moderate cost are used and one watt output at low distortion is achieved. The receiver incorporates a recently described limiter and discriminator circuit giving good a.m. suppression. Some constructional and alignment details will be given in Part 2, and Part 3 contains the results of performance tests made on a prototype model.

Transistor V.H.F./F.M. Receiver

1. DESIGN CONSIDERATIONS AND CIRCUIT

By R. V. HARVEY*, B.Sc. A.M.I.E.E.

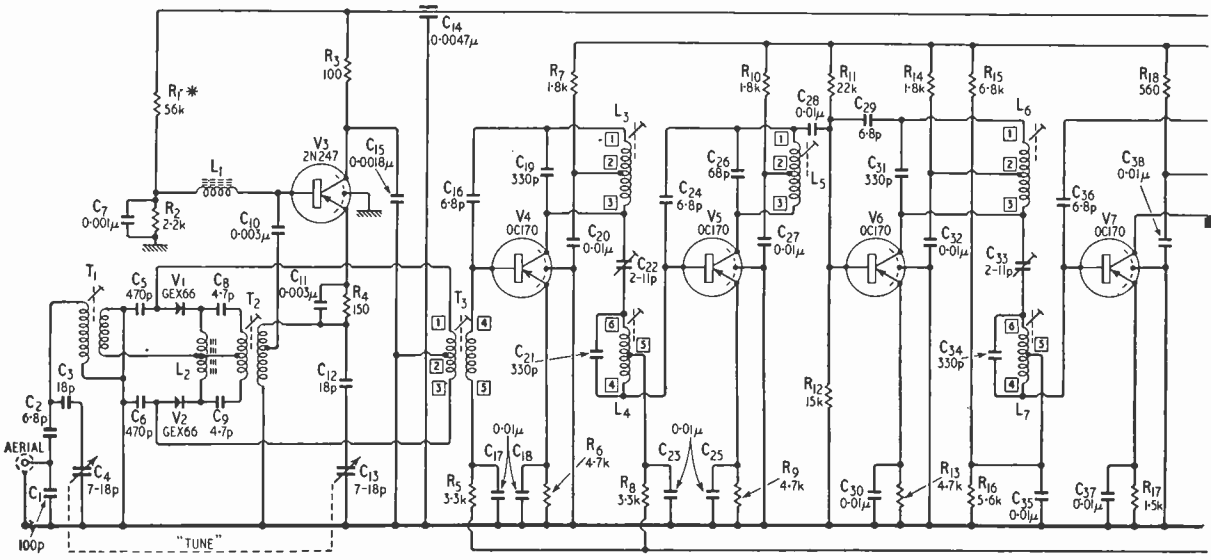
IN designing a transistor broadcast receiver, there may be a tendency to make undue concessions to the small size and low power consumption of transistors which might result in a sacrifice of performance. In applying transistor techniques to the design of a v.h.f. receiver for f.m. broadcasts, it was considered desirable to avoid this approach and to produce a receiver which without resorting to excessive expense or complexity had a performance equal, in the more important respects, to that of the better-quality domestic valve receiver. In particular, adequate suppression of amplitude modulation, adequate sensitivity and reasonable fidelity of sound reproduction were regarded as essential requirements for such a receiver.

General Design

The receiver is continuously tunable from 87 to 100 Mc/s. In the initial design, consideration of the availability and cost of transistors having a useful gain at 100 Mc/s led to the decision not to use an r.f. amplifier. However, the RCA Type 2N247 drift transistor was readily available and has sufficient gain to be used as an oscillator at frequencies

*B.B.C. Research Department.

Fig. 1. Theoretical circuit diagram. Centre-tapped choke, L_2, and capacitors C_8 and C_9 may not be needed—T_2 is then joined directly to V1 and V2, the mixer diodes. Shown dotted are components for boosting bass for loudspeaker equalization: other component changes are C_{52}, reduce to 0.5μF, and C_{49}, reduce to 1,200pF. Asterisk against component value indicates adjustment during setting up.



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from 77 to 90 Mc/s and to drive a diode mixer adequately for efficient conversion of the signal to the standard i.f. of 10.7 Mc/s. Radiation of oscillator power from the aerial is minimized by using a balanced mixer circuit. The effect of supply-voltage changes on the oscillator frequency is almost completely removed by shunting the oscillator supply by a Zener stabilizing diode. The remaining frequency drift is then quite small and is mainly caused by changes in room temperature as the "warming-up" effects due to internal heat production are negligible.

The i.f. amplifier must have a maximum gain of about 90 dB to make up for the conversion loss of the mixer and to supply sufficient power to the limiter; the latter can then operate satisfactorily at signal input levels down to about 30 μV. A stage gain of 22 dB could be achieved with adequate stability using the Mullard Type OC170 transistor and the required overall gain and bandwidth was finally obtained by cascading four such stages, using alternate single- and double-tuned coupling circuits. As miniaturization was not proposed, the i.f. amplifier could extend over some ten inches of chassis to avoid unwanted feedback.

It has been emphasized elsewhere that efficient suppression of amplitude modulation is essential to reduce the effects of co-channel interference[1] and multipath propagation[2, 3]. A simple valve receiver has been described[4] which achieves a good performance in this respect by incorporating a discriminator combined with a "dynamic diode" limiter. The limiter operates with a self-generated bias proportional to the mean level of the applied signal and suppresses rapid changes in level. The bias is also used for a.g.c. so that for slower changes in level, the variation of a.f. output is kept small but is not completely suppressed so enabling strong and weak transmissions to be distinguished from one another when tuning. As this combined limiter and discriminator is a passive circuit, it was adopted with little change in the transistor receiver.

A maximum a.f. output power of one watt, delivered to an 8-in high-flux-density loudspeaker, was considered sufficient for domestic reception. A transformerless Class-AB push-pull output stage, using G.E.C. Type GET115 transistors operating from a 12-volt supply, gives the required output into a loudspeaker impedance of 15 ohms. The phase-shift in these transistors at high frequencies is sufficiently small to allow about 20 dB of negative feedback to be applied to the input of the driver stage whilst maintaining adequate stability. Three additional stages, one incorporating the gain control, provide the necessary a.f. gain.

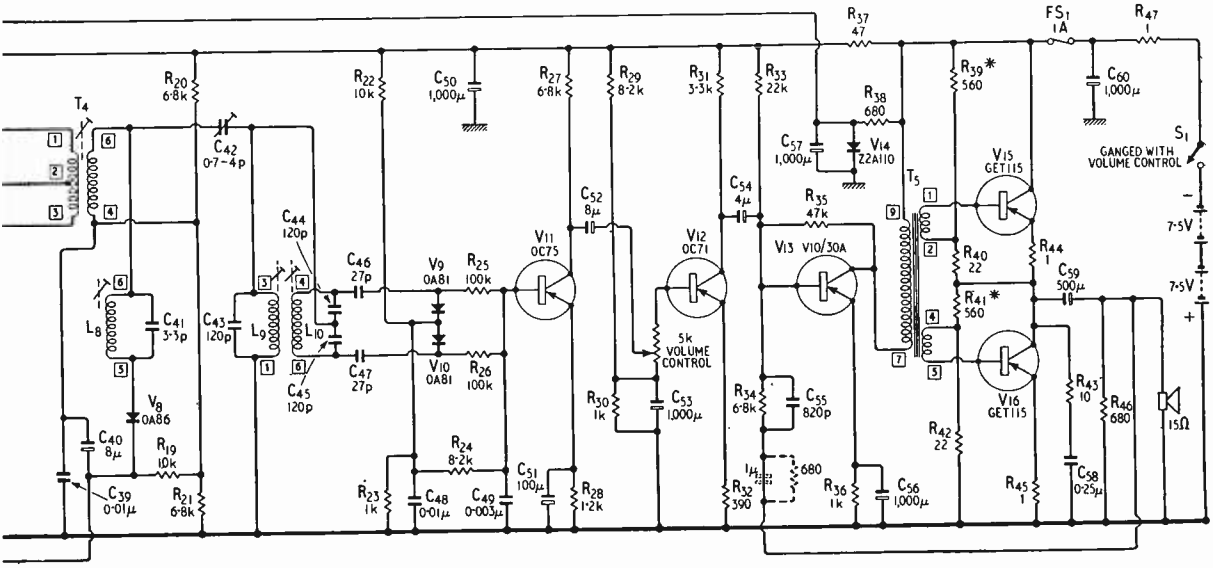
For acceptable fidelity of sound reproduction, a fairly large "table-model" size of cabinet measuring 22×16×10 in was chosen. As the mean power consumption of the receiver is less than one watt, there is no need for internal ventilation. The cabinet was therefore constructed as a vented enclosure with a rigid back and with internal acoustic damping. Fixed bass- and treble-lift circuits were subsequently added to the a.f. amplifier to preserve a fairly uniform axial response.

Description of Circuits

The circuit diagram is shown in Fig. 1. Lists of suitable components and coil- and transformer-winding data will be given in Part 2.

R.F., Oscillator and Mixer.—The r.f. and oscillator circuits are each tuned by one section of a two-gang capacitor. The effective capacitance range is reduced to a variation from 5 to 7 pF by adding series 18 pF capacitors and restricting the angular swing of the tuning capacitor to 150°. To assist in the tracking of the two circuits, the r.f. coil is of slightly lower inductance (0.5 μH) than the oscillator coil and is loaded by an additional capacitive network which transforms the aerial impedance of 75 ohms to about 20 kΩ. The load imposed by the mixer and the coil loss is of the same order, resulting in an effective Q-value of about 50 for the r.f. tuned circuit.

The oscillator coil is connected between the emitter and collector of a 2N247 drift transistor, its base being tapped in close to the emitter end of the coil. This gives the required positive feedback, bearing in mind that the phase angle between collector and emitter currents approaches 180° at 90 Mc/s. As the oscillator frequency is dependent on collector



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capacitance, part of which depends on the collector potential, the supply is stabilized at 10.5 volts by a Zener diode, S.T.C. Type Z2A110. The collector current is held stable at 1 mA by an emitter resistor of 150 ohms, the base being fed through a small choke from a potential divider across the battery supply.

The mixer consists of two GEX66 point-contact diodes driven in push-pull by the oscillator; the r.f. coupling is connected between the mid-point of the oscillator coil and the earth. The balanced circuit reduces the oscillator voltage appearing at the input to less than 1mV and direct i.f. pick-up through the mixer is minimized by the use of inductive coupling. To prevent spurious f.m. of the oscillator by input signals of 100 mV and greater, it may be necessary to insert capacitance (C_8 and C_9) in series with the mixer diodes and the oscillator couping, as shown in the circuit diagram; the centre-tapped choke, L_2, then provides a d.c. path for direct current in the mixer, which is about 200 μA. If C_8, C_9 and L_2 are omitted, V1 and V2 should be connected directly to T_2 primary. The output impedance of the mixer is about 600 ohms and the conversion loss of the unit at 90 Mc/s is approximately 12 dB.

I.F. Amplifier.—The balanced output from the mixer is transformed to an unbalanced impedance of 300 ohms by the first i.f. tuned circuit and applied to the base of the first i.f. stage. The amplifier consists of four OC170 transistors in common-emitter connection. The maximum-possible unilaterilized power gain is about 120 dB, of which, in the interests of stability, about 30 dB is deliberately lost. This is achieved by choosing the L/C ratios of three interstage-coupling circuits to obtain a loss of about 10 dB in each coupling with unloaded Q-values of 100. The overall response is largely determined by these three circuits, one single-tuned and two coupled pairs, and is 3 dB below the maximum at about $\pm$90 kc/s from the centre frequency. Non-critical neutralization is effected by 6.8-pF fixed capacitors.

The first two OC170 stages operate at a maximum collector current of 1 mA, developing a potential drop of five volts across their emitter resistors. The gain of the receiver may be reduced by up to 50 dB by applying a.g.c. voltage to the bases of these two stages The third and fourth stages operate with fixed bias and the last stage has a collector current of 3 mA in order to deliver a maximum i.f. power of about 5 mW to the limiter and discriminator circuits.

Limiter, A.G.C. and Discriminator.—The action of the limiter and discriminator circuits is described only briefly here; a more detailed explanation has been given elsewhere[4].

The collector of the last i.f. stage is connected to the primary of a tightly coupled step-up transformer. The secondary winding is shunted by an amplitude-modulation limiter in the form of a peak detector with a long-time constant load. As the mean load resistance imposed by the limiter is approximately one-seventh of the remaining shunt resistance across the secondary winding, the limiter will function with modulation depths of up to 87%; at greater depths the limiter will not operate at troughs of modulation. The limiting efficiency is improved by the addition of a third-harmonic filter (L_8, C_{11}) in series with the diode[5].

An a.g.c. voltage is applied to the bases of the first two i.f. transistors from one end of the limiter load resistor. The other end of the load is returned to a point on a potential divider across the d.c. supply; thus the a.g.c. bias is maintained at -5 V in the absence of a signal, decreasing to -0.5 V for large signal inputs. The a.g.c. is applied to the i.f. stages without any more long-time-constant filtering so that amplitude modulation such as aircraft flutter is effectively controlled when its frequency is too low for the limiter to operate.

A Foster-Seeley type of phase discriminator is coupled to the limiter by a small series capacitor which, with some of the primary reactance of the discriminator transformer, forms an impedance-inverting network. The discriminator is thus fed from a high-impedance source (as is essential for its correct operation) derived from the very low impedance presented by the limiter.

A capacitive centre-tap is used on the secondary of the discriminator transformer and the inductive coupling between primary and secondary is 1.5 times the critical value. The combined primary and secondary voltages are applied to two shunt diodes with load resistors returned through a relatively small common resistor. This resistor forms the source impedance for the first a.f. stage, carries the base bias for the transistor and, with the input impedance of the transistor and a shunt capacitance, forms the de-emphasis network. By connecting the diodes and their load resistors so that the difference-current flows in a small common resistor, the "dual" of the conventional Foster-Seeley circuit, which applies the difference voltage to a high-value shunt resistor, is formed. The lower output impedance of the former circuit is clearly more suited to supplying a transistor amplifier.

A.F. Amplifier and Output Stage.—The output of the first a.f. stage following the discriminator is passed to the a.f. unit, in which an output power of 1 watt is obtained from a minimum signal of 0.5 V across the 5-kΩ a.f. gain control. There are two intermediate common-emitter stages, a coupling transformer and a pair of output transistors operating in Class AB for power economy. There is no output transformer as the 15-ohm loudspeaker forms an optimum load connected (via a capacitor) between the junction of the output transistors and the chassis. The quiescent current in the output transistors is about 7 mA and, to give minimum cross-over distortion adjustment of the bias is required. About 17 dB of negative feedback is applied to the preceding stage from the loudspeaker through a correcting network and 9 dB feedback from the collector to the base of that stage. By choosing output transistors having moderate power-handling capacity and relatively high cut-off frequency, negative feedback is easy to apply and the design of a very efficient output stage has been possible.

Loudspeaker Compensation.—The 8-in diameter loudspeaker, when mounted in an open cabinet, gave a somewhat irregular response. By making the back of the cabinet of rigid board, treating the inside surfaces with layers of fibre-board and wood-wool, and cutting a 2-in diameter vent in the front panel, the gross irregularities were removed. The smoothed axial response has a progressive loss above and below 2 kc/s, amounting to 8 dB at 100 c/s and 6 dB at 10 kc/s. The circuit shown in Fig. 1 gives a substantially uniform audio-frequency response; to

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compensate for the response of the particular loudspeaker and cabinet used here, the circuit can be modified slightly. Partial electrical compensation at high frequencies can be provided by simply reducing the de-emphasis time-constant to 30μs (C_{49} is reduced to 1,200 pF). Partial bass-compensation is effected by inserting a 680-ohm resistor shunted by a 1-μF capacitor in the a.f. feedback loop, between C_{59} and C_{55} (shown dotted). To prevent the gain rising to excessively high levels at very low frequencies, the coupling capacitor between the first two a.f. stages (C_{52}) is reduced to 0.5μF.

Power Supply

The receiver will operate satisfactorily at supply voltages of between 11 and 15 volts; the upper limit is set by the rating of the output transistors and the lower limit by the Zener diode stabilizing the oscillator supply. The current consumption is about 22 mA with no signal and about 30 mA at normal listening level. A convenient supply for the table model receiver is provided by two 7.5-volt dry batteries, each measuring $5\frac{1}{8} \times 2\frac{1}{4} \times 3\frac{3}{4}$in. Using this supply, costing 6s. 6d., the estimated life of the batteries is about forty days if the receiver is used for four hours every day.

(To be continued)

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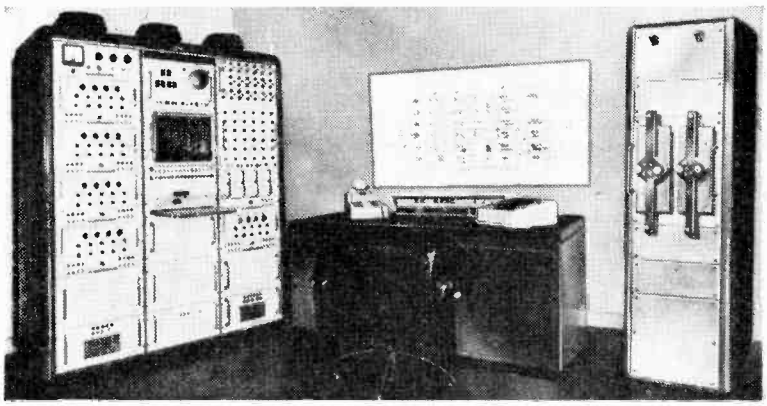
HYBRID COMPUTING SYSTEM

Analogue and Digital Methods Combined in New Equipment



IT has been recognized for some time that the ideal electronic computing system is one which combines the advantages of both analogue and digital techniques. On the analogue side there are the advantages of high speed of operation, ease of programming even with very complex calculations, ability to alter the input information during computation, relatively small size and low cost. On the digital side the principal advantages are high accuracy, convenience of input and output facilities, extensive storage and stability with time.

Unfortunately, in practice one cannot get the advantages without the disadvantages, and any combination of the two techniques must take into account such things as the limited accuracy and lack of storage of the analogue computer and the relatively slow speed and high cost of the digital machine. In short a particular pattern of advantages and disadvantages has to be selected, depending on what sort of work the hybrid computer is required for. This pattern will, of course, determine the particular way in which the analogue and digital electronic circuits are combined.

An extremely versatile combination of techniques has been adopted in the new hybrid computing system developed by Redifon (who are perhaps better known at present for their flight simulators and communications equipment). It is called RADIC, which stands for Redifon Analogue Digital Computing system. Basically it is an analogue computing system with digital input, output and storage facilities—the storage equipment being an unusual design giving quantization in the time scale. It is, above all a *system*, from which groups of computing elements can be selected for particular types of calculation —not a fixed-size computer. A major field of application which depends largely on the analogue facilities is the analysis and simulation of industrial and other control systems. Other applications, such as statistical analysis, linear programming and analysis of the transfer functions of commercial and other operations, depend more on the digital facilities.

Since the RADIC is basically analogue in its mode of calculation it is not intended for commercial and accountancy work, where 100 per cent accuracy is essential (for example, in calculating payrolls!) There are, however, a good many commercial calculations that do not require exact figures since the input information is not 100 per cent accurate, but where an answer of 99.9 per cent accuracy is most valuable if it can be produced quickly—as it can by analogue methods.

The electronics of the RADIC system, then, com-

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prises an assembly of drift-corrected d.c. amplifiers, electronic multipliers and diode-network function generators operating on well-known principles.* These electronic computing elements, backed up by electro-mechanical servo-operated integrators and multipliers, perform the operations of addition and subtraction, multiplication and division, integration and differentiation with respect to time and the generation of mathematical functions (e.g., sines, squares, logarithms). The elements can be interconnected in various ways, depending on what type of computation is to be performed, by means of a central "patchboard."

As already mentioned, digital devices are used for feeding numerical data into and out of the analogue computing elements, and also for storage purposes. There are two keyboards for input information. One, on a modified "Addo X" digital printer, is for feeding numerical data into the storage system. The other keyboard is for the automatic setting of coefficients in the analogue computing elements. There are also two devices for digital output information, an illuminated number display (on both the main computer and the central desk) and a print-out mechanism (on the "Addo X" unit). Digital storage is provided by a magnetic tape equipment, which can also be used for the simulation of time delays in control systems and for other special purposes.

All these digital input, output and storage devices operate in the "parallel," as distinct from the "serial," mode—that is, all the pulses representing a number occur simultaneously on separate wires, not in sequence on a single wire. This method, using the binary-coded decimal system of representing numbers, enables the digital units to match the high speed of the analogue computing elements. The translation of data from digital to analogue form and vice versa is done by analogue-to-digital and digital-to-analogue converters.

Magnetic Storage

The feature of the RADIC system which, perhaps more than any other, distinguishes it from conventional analogue computers is the magnetic-tape digital storage system. This extends the field of use of the system to complex types of input data which the normal type of analogue computer is unable to handle. Physically this storage system takes the form of a separate transportable cabinet —the reason being that it can be used on its own for certain types of calculation or taken to a remote site to record characteristics of, say, an industrial plant. It contains two tape decks, a digital encoder for translating input data into a form suitable for storage, and a digital-to-analogue converter for translating digital data from the tape into a form suitable for the analogue computing elements. The magnetic tape is 35mm wide and has sprocket holes like cinematograph film. It will record 16 channels simultaneously.

As mentioned earlier a new principle is used for the storage of digital information on the tape. This is the process of quantizing the time scale as well as the data recorded. Using a sprocket drive system, the tape is moved in separate small steps, and digits are recorded and read-out while the movements are taking place.

By this means the stored information is put under more precise control than it would be on a continuously moving tape, and, in fact, the small steps are accurately synchronized to the read-in/read-out circuitry. Although the tape always moves at constant speed over the magetic heads, the intervals of time between successive movements can be extended at will. As a result the average tape speed can be precisely varied over an extremely wide range of speed. The pulse which controls the stepping action can be set at a constant rate or made to vary in accordance with some other quantity involved in a computation. Incidentally this new time-quantizing method of operation dispenses with the cumbersome and costly circuitry normally required for slow-moving tapes and flux-sensitive magnetic heads.

Time-delay Applications

One special use of this storage system is that it can be used to simulate time delays which may occur in process control systems. Data is recorded on the tape and then read out by a reading head which is physically displaced from the recording head—the time taken for a point on the tape to pass from the recording head to the reading head being determined by an accurately controlled number of steps, each of which takes an accurately controlled interval of time.

In addition this time delay facility is used for correlation computing, in which data stored on the tape is continuously compared with data on other parts of the tape (displaced by known intervals of time) in order to detect periodicities. For this work it is necessary to be able to automatically alter the spacing between the two heads by an electrical signal to give a series of different time delays as the computation proceeds. This is done by an ingenious mechanism in the tape deck based on differential movement between two tape driving sprockets.

Correlation computing (which is explained at some length in "Electronic Computers"*) can be performed on either analogue or digital input data. In the RADIC system it is intended to be applied mostly to digital information for statistical analyses —particularly the analysis of systems, whether industrial plant or commercial operations, which defy normal mathematical treatment. For this field of applications the digital storage unit, combined with built-in integrators and multipliers (required in computing correlation coefficients), is supplied as a separate equipment which is small enough to be transported to remote sites where recordings may have to be made *in situ*.

Overall control of the RADIC computing system is given by a bank of press-buttons situated on the control desk near the digital input and output equipment. Some of these buttons, for example, provide an elaborate selection system which enables the voltages at the outputs of any of the analogue computing amplifiers to be indicated as numerical values on the digital number display (actually a digital voltmeter).

The equipment shown in the photograph is a medium-sized assembly incorporating the maximum variety of analogue and digital units.

* The basic principles of analogue computing techniques were outlined recently by G. B. Clayton in "Simple Analogue Computer" in *Wireless World* for May, 1960. For additional information, see "Electronic Computers," 2nd edition, by T. E. Ivall, Iliffe, 1960.

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CORNER BAFFLE LOUDSPEAKER MOUNTING

METHOD OF DOUBLING THE EFFECTIVE BAFFLE SIZE

By H. C. PINFOLD

THE recent revival of baffle mounting of loudspeakers initiated by G. A. Briggs led the writer to do some experimenting with this form.

It is known that, given a large and rigid enough sheet of wood, preferably about seven feet square and several inches thick, and a speaker of really low free-air resonance, then plain baffle mounting gives remarkably clean bass free from the boom which is often associated with the various types of enclosure mounting.

However, few people have the space for such large baffles as are necessary for reproduction right down to 40c/s.

Fig. 1. Conventional baffle mounting of a loudspeaker. The dotted lines show the shortest paths connecting the front and back of the cone.

The purpose of the baffle is to keep the front and back radiations separate from one another for as great a distance as possible. The speaker is usually mounted near the centre of a square or rectangular board and thus effective separation of the front and back waves is achieved for a distance of only twice one half of the size of the board (see Fig. 1).

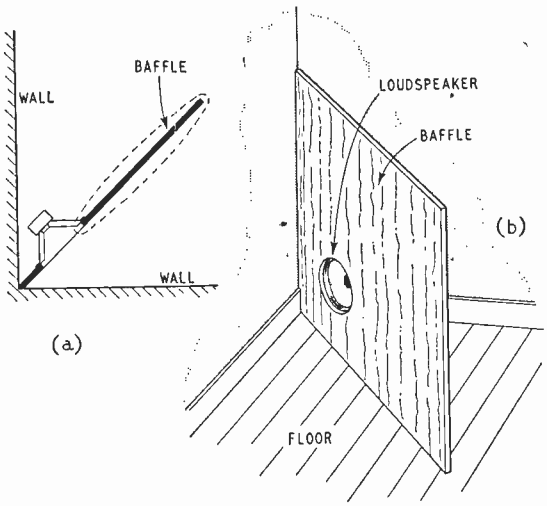

Fig. 2. Plan (a) and perspective (b) views of corner baffle-mounted loudspeaker.

However, if the speaker is mounted near a corner of the board, as near to the edges as the depth of the frame and magnet will allow, and the board is placed diagonally into the corner of a room as in Figs. 2(a) and 2(b), then, assuming the board to be the same size in both cases, it will be seen that the shortest path between the back and front of the speaker in Fig. 2 is nearly twice that in Fig. 1. Alternatively, the arrangement of Fig. 2 will give, for a board of half the size, at least as good results as that of Fig. 1.

Loading of the speaker cone is much improved in the corner arrangement, as both sides of the speaker face into spaces which are horn-like in shape. Furthermore, when a speaker is mounted on a conventional baffle and placed as is usual near to a wall, there is an inevitable interaction between the cone and the wall so that a standing wave is built up. This effect is avoided in the corner arrangement.

There is no critical tuning to be done with this sort of mounting, which works well with a variety of speakers. The only factor that governs the choice of speaker for this mounting, as for all baffle arrangements, is the bass resonance of the unit, which should be as low as possible. The Wharfedale 10-in Bronze FSB unit (bass resonance about 35c/s) sounds remarkably good and is not costly, but no doubt a high-flux 12-in unit would be more beefy.

As for the baffle board itself, 3 feet square of 1-in block board gives very fine bass and exhibits no tendency to panel resonance. Two 1-in boards screwed together would be better, or a sand-filled sandwich would be better still. A rectangular board might also be preferable. Sealing to the floor and walls is not critical, but some shaping is necessary around skirtings, etc. The board is self-supporting.

CLUB NEWS

Essex.—The Silverthorn Radio Club is holding its annual field event over the August Bank Holiday weekend at Carroll's Farm, Sewardstonebury, near Chingford. Station GB3SRC will operate in the 160-m band. The club meets on alternate Fridays at the South Chingford Community Centre, Hall Lane, London, E.4.

London.—The secretary of the International Short Wave Club (Arthur E. Bear, 100 Adams Gardens Estate, London, S.E.16) offers to send a specimen copy of the club's news bulletin "International Short Wave Radio" to any reader of *Wireless World*. The duplicated four-page monthly bulletin gives up-to-date news of short-wave broadcasting stations, including schedules and operating frequencies.

Middlesex.—At the meeting of the West Middlesex Tape Recording Club on July 28th Angus McKenzie, of Olympic Sound Studios, will speak on stereophonic recording and reproduction. The meeting will be held at 8.0 at the St. George's Hall, Lancaster Road, Southall Broadway.

Monmouth.—Preparatory to forming an amateur radio club in Blackwood, Mon., meetings are being held each Friday at 7.0 at the Blackwood Miners' Welfare Institute. Further details are obtainable from P. M. Fulton, 36, Sunnybank Road, Blackwood.

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OPTICAL LINE ELIMINATOR

DISPERSIVE SCREEN UNDER DEVELOPMENT BY THE GERMAN FIRM SABA

ONE of the arguments put forward in favour of changing British television line standards from 405 to 625 is that on the larger screens (21-inch and upwards) the line structure is disturbing. It is interesting to find that the same criticism is made of high-quality pictures on the 625-line standard in Germany, according to a recent survey by SABA, the Black Forest firm of receiver manufacturers. At a recent international press conference, on the occasion of the 125th anniversary of the foundation of the firm, it was stated that, with all possible improvements in the matter of optimum phase and amplitude characteristics, fully automatic tuning and contrast control, etc., already incorporated in their sets, line structure, according to some of their customers, was the only performance factor requiring improvement. The spot-wobble technique is, of course, expensive and the production of an elliptical spot is difficult with the short necks and complicated deflection coils now necessary with wide-angle tubes.

The solution being developed by SABA is purely optical and consists of a transparent plastic sheet, with horizontal parabolic corrugations embossed on one side. This screen is mounted a short distance in front of the cathode ray tube and light from the screen is dispersed vertically (Fig. 1) but not horizontally, so that the resolution along the line is unaffected. An essential feature of the method is that the pitch of the corrugations should be small compared with the picture line spacing. In a specimen examined by this journal the rulings are 125μ (0.125mm) wide, i.e., about 200 per inch, and the height of the parabolic arc is 8.5μ. There are thus about 8 lenses to every line of a 405 picture on a 21-inch tube (line spacing 1mm).

To test the efficacy of the device a photographic plate was made of two lines each $\frac{1}{2}$mm wide and separated by a dark space of the same width (very approximately 405-line 21-inch conditions). This was illuminated from behind and photographed through the screen, the left-hand edge of which was resting on the plate and the right-hand edge raised about $\frac{3}{8}$-inch. The result is shown in Fig. 2 from which it will be seen that the lines merge when the spacing is about $\frac{1}{4}$ inch (6mm); when the distance is increased, multiple lines reappear. In practice optimum spacing would, of course, depend also on the thickness of the glass of the c.r. tube. Fig. 3(a) is a test plate also ruled to simulate 405 lines on a 21-inch tube and is reproduced full size, so that it can be judged at any desired viewing distance. Fig. 3(b) is an untouched photograph of the plate taken through the SABA screen.

Research is proceeding and in particular is directed to producing a clearer screen—the specimen we tested was translucent, due to minute score marks made by the tool used in cutting the master plate.

The beauty of the scheme, which gives the same result as spot wobble, is its cheapness; replicas are easily cast in thermoplastic material. And those who like to see the lines can always remove the screen!

Lenticular screens are not in themselves new—they have been suggested for modification of picture aspect ratio (*Wireless World*, December 1952, p. 502) and for stereoscopic television (*Wireless World*, July 1953, p. 298)—but this latest application to the removal of lininess promises more immediate benefits. It is certainly cheaper than changing our transmission system to 625 lines, or should we now say, in view of Continental experience, to 4,050 lines?

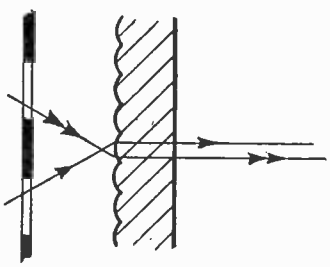

Fig. 1. Vertical section illustrating the principle of the dispersive screen under development by SABA.

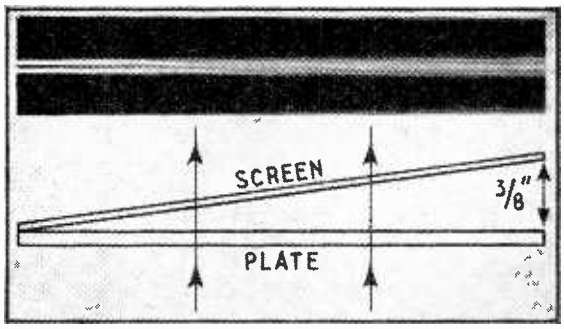

Fig. 2. Variation of visible line structure with distance between tube and screen.

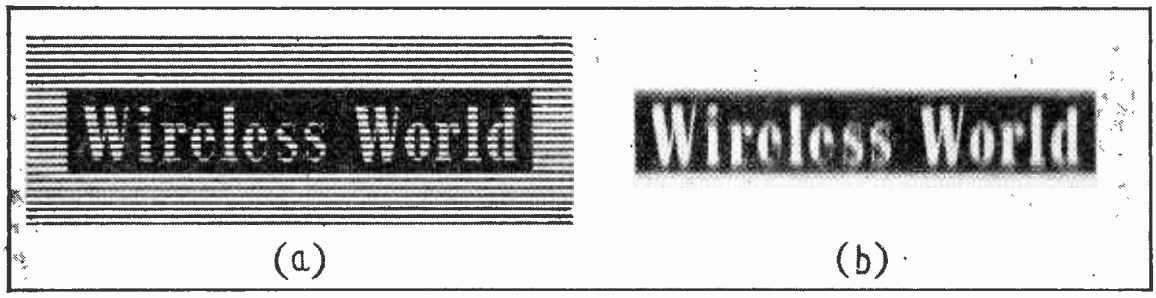

Fig. 3. Test specimen (a), reproduced full size to represent 405 lines on 21-inch tube, and (b) viewed through the SABA dispersive screen.

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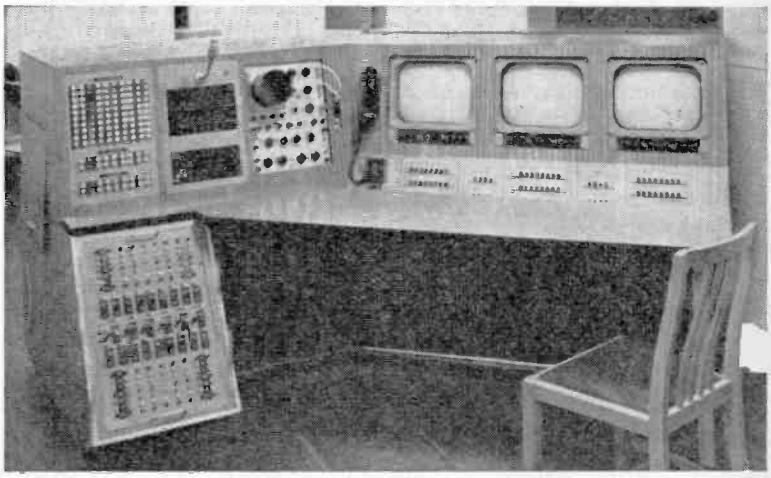
B.B.C. Television Centre

A WHOLE issue of this journal would be quite inadequate to cover all the interesting features of the new B.B.C. Television Centre in West London. We shall, therefore, describe and illustrate from time to time points of special interest in the installation.

Co-ordination and ease of control have been key words in the planning of the operational control areas associated with each of the seven studios grouped around the central ring building. The first transmission from the Centre was on June 29th. Only one studio, of 8,000 sq ft, is so far in use.



Eleven flying-spot film scanners for both 35-mm and 16-mm films are being installed in the Telecine Suite. At the central control desk illustrated above the outputs from all the machines, which are housed in adjacent bays, are monitored and distributed. Facilities are provided for remote starting and stopping of the film scanners from several points in the control system.

Control consoles for studio lighting (left) and vision (right) are adjacent so that each controller sees the same set of monitors. By the use of six joystick-type controls (ringed in the photograph) one operator can remotely control the iris and the picture black level of each of up to six cameras in the studio. Each of the joystick controls has three functions. Moving over a quadrant varies the camera lens aperture; a knob on the control is rotated to adjust the picture black level and pressure on this knob switches the camera output from one picture monitor to another. This last facility enables the output from each camera to be displayed in turn on a single monitor for matching, thus eliminating possible differences in individual monitors. Alongside each monitor is a miniature waveform display. The waveform is about 5-in high but the time scale is compressed to about 1¾-in as the controller is mainly concerned with checking voltage levels.

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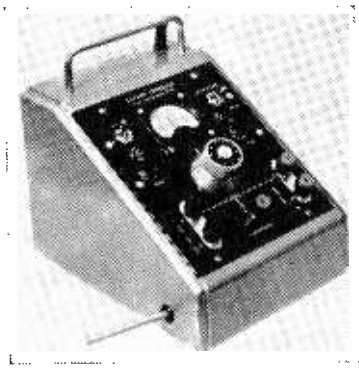
Technical Notebook

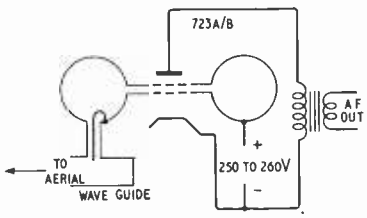
Field Plotting using a resistive sheet rather than an electrolytic tank was first described as long ago as 1845 by Kirchhoff, who used thin sheets of copper. However, this technique has been lying in abeyance pending the discovery of a more suitable sheet material. Creed's "Teledeltos" paper is used in a relatively inexpensive plotter recently introduced by Servomex (Type FP92). To plot a field, the paper is painted with silver electrodes which are then



connected to the internal supply voltage on the Servomex plotter. This voltage is divided down to an accuracy of 0.1% by means of a calibrated potentiometer, and then fed via a balance-indicating meter to a probe. By searching the resistive paper with the probe for balance points, a field line corresponding to the chosen dividing ratio can be built up. Non-uniformities in the resistivity of the sheet normally limit the accuracy of field measurements to about 7%. This accuracy is, however, not much worse than what is normally achieved with an electrolytic tank. In any case, in practice, fields are usually plotted only in order to determine correction factors to theoretical formulæ; so that errors, being only corrections to corrections, need not be kept very small.

Prefabricated Electronic Bricks—ready-assembled circuit modules—can cut down development time spent on a control-engineering or data processing problem by eliminating the work of designing individual circuits. A particular range made by Mullard are slim, colour-coded plastics "boxes" of guaranteed performance specifications covering the commonly used circuit functions. Typical units are AND/OR gates, timing and relay-operating circuits called "Norbits" (for control purposes) and flip-flop, pulse shaper and inverter-amplifier stages called Combi elements (for digital circuits). By giving only a performance specification the manufacturers can take advantage of advances in techniques (for instance, complete solid-state circuits) without, at the same time, rendering obsolete existing apparatus. Transistors are used throughout, so that battery operation is reasonably economical, and the modules are designed to connect together compatibly in a manner suited to their functions. Norbits have long, flexible flying leads for use with terminal blocks while Combi-elements have short, stiff tinned wires suitable for fitting into printed wiring boards.

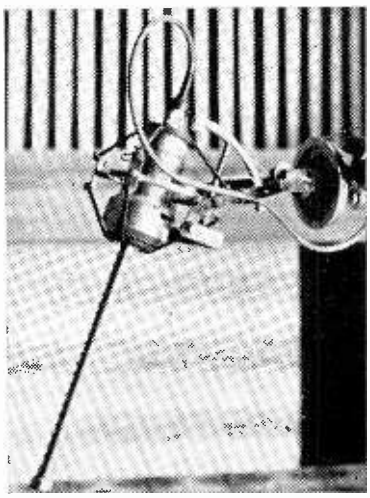
Klystron Detector for Microwaves is the subject of an article by Dr. Koryu Ishii on p. 77 of *Electronic Industries* for November 1959. Dr. Ishii made the widely available 723A/B 3-cm reflex klystron act as an a.m. detector with a 3-dB bandwidth of 50Mc/s at 9.2Gc/s and a gain (for weak signals) of between 10 and 30dB. As can be seen from the diagram, the repeller is connected, via the load, to the cathode and an h.t.



of about 250V is applied between the cavity structure and cathode. Electrons accelerated by the field between cathode and cavity can pass through the modulating electrodes (lips) of the cavity and reach the reflector. When, however, the cavity is excited by signals at its resonant frequency the lips will modulate or bunch the electron flow, retarding and accelerating on alternate half cycles of the 9.2Gc/s signal. The accelerated groups will reach the reflector, where they constitute the signal current. The retarded groups, on the other hand, will not possess sufficient speed to reach the reflector and will return, under the influence of the potential gradient between the reflector and cavity, to the cavity lips. If the relative phase of the signal on the cavity and the returned bunches is correct, then the returned bunches will give up the energy gained from the reflector-to-cavity field, so reinforcing the signal. The reinforced signal exerts a greater effect on the electron beam, in the same way that the klystron normally goes into oscillation. Cavity potential is fairly critical: results given show that a 3dB gain loss is caused by a ±0.25-V change in h.t.; however, for the same loss of gain a 1.3-V variation in heater potential is permissible.

Peak Pulse Power Increase could be obtained by means of pulse shortening according to an article by C. E. Cook in *Proc.I.R.E.* for March 1960. The method of shortening suggested depends on providing a pulse in which the frequency changes linearly with time. This pulse is then passed through a filter which produces a delay which also changes linearly with time but in the opposite sense to that in which the frequency changes linearly with time in the pulse. The beginning of the pulse is then delayed more than the end and the pulse duration is decreased. If a passive delay network is used, the total energy in the pulse must remain constant so that the peak pulse power must increase in proportion to the decrease in the pulse period.

New Microphone brought into television studio service by Tyne Tees Television and manufactured by the American firm Electrovoice (Model 642) has a normal dynamic cardioid response characteristic up to 500c/s,



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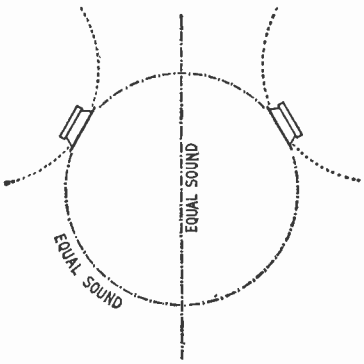
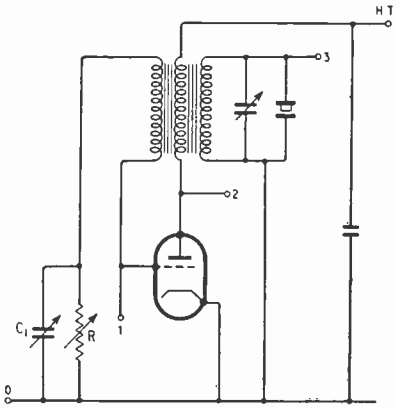
but above this frequency distributed openings at the front of the diaphragm make the response much more directional.

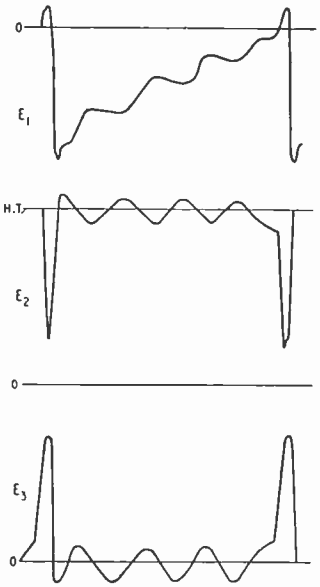
Stereo Listening-area Enlargement can be obtained by using loudspeakers having a figure-of-eight rather than an omni-directional polar response, according to an article by B. B. Bauer in the April 1960 issue of the American *Journal of the Audio Engineering Society*. When two loudspeakers are used to reproduce stereo, satisfactory results are obtained near places where the two loudspeakers produce equal sound outputs when fed with equal in-phase signals. In most cases such equal sound outputs are produced along the line of symmetry between the loudspeakers, and satisfactory stereo is produced in an area around this line. With figure-of-eight polar response loudspeakers, however, such equal sound outputs are produced not only along the line of symmetry between the loudspeakers, but also along the circle common to the polar responses of both loudspeakers (see diagram), so that satisfactory stereo is produced in an additional area around this circle. One way of obtaining a figure-of-eight response is to mount a loudspeaker on a baffle smaller than the sound wavelength of the highest frequency of interest, although unfortunately at low frequencies such baffle mounting results in a sound output which falls as the frequency decreases.



A Sub-harmonic Crystal Oscillator requiring only a single triode valve in a blocking oscillator circuit has been constructed at the U.S. National Bureau of Standards. As shown in the illustration at (*a*) the crystal is coupled to the blocking oscillator by means of a tertiary winding on the transformer. Alternatively the crystal could be connected across either the grid or anode windings, but the third-winding arrangement was found to be preferable. Typical waveforms at different points on the circuit are shown at (*b*) in the illustration.



(a)



(b)

The fundamental frequency of the blocking oscillator is determined primarily by the time constant of C_1 and R in the grid circuit, so with C_1 or R or both variable a wide range of output frequencies can be generated. Each output pulse of the blocking oscillator "shock excites" the crystal, and the voltage so generated is used to synchronize the oscillator at a sub-harmonic of the crystal frequency.

Frequency division ratios as high as 10,000 to 1 have been obtained with a few crystals, but such extreme ratios would seldom be of practical value, since a small change in circuit constants could cause the output frequency to change from, say, 1/10,000 to 1/10,001 of the crystal's fundamental frequency. More realistic are divison ratios of several hundred to one.

The potentially wide range of division ratios obtainable means that a desired output frequency can be produced from any of several available crystals, or conversely, a single crystal can be used to produce a large number of crystal-controlled sub-harmonic outputs.

Interference with Television can occur in many ways—some difficult, some easy, to track down. Usually television interference by amateur transmitters falls into two categories—either pick-up by the i.f. circuits of the set, or the radiation of harmonics in the television bands. However, it can be more complicated, as N. Ashton notes in a letter on p. 424 of the March 1960 *R.S.G.B. Bulletin*. From the description given it seems that the process is like this: if a strong signal enters a television receiver it may cause cross modulation between sound and vision, so giving a 3.5Mc/s beat. When the interfering signal is near 3.5Mc/s, or a sub-harmonic, it can beat with the cross modulation, this beat being modulated back on to the sound and/or vision signals! The obvious cure is a high-pass filter of cut-off point 40Mc/s or so, placed in the aerial lead; but this does not always work, due to the use of small isolating capacitors at the chassis end of the aerial socket-to-tuner cable. These capacitors may have a high impedance to a signal as low in frequency as 3.5Mc/s, thus pick-up on the cable "outer" is transferred to the receiver. Consequently the filter has to be fitted inside the receiver, as close to the tuner as possible.

Motor-driven Automatic Correct-range Selection is an unusual feature of the new American Knight a.c. valve voltmeter kit shown assembled in the photograph: all the 11 ranges can be driven through in 2½sec. Full scale deflections can be produced by potentials ranging from 3mV to 300V, and the response is within ±1dB from 20c/s to 2.5Mc/s. As many as 10 valves are used in the circuit. Further particulars may be obtained from Ad. Auriema Inc. of 85 Broad Street, New York 4, U.S.A. or from Auriema—Europe S.A. of 27 Rue du Berger, Brussels, Belgium.

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WORLD OF WIRELESS

Broadcasting Inquiry

ON July 13th the P.M.G. announced in the House the setting-up of a committee of inquiry into the future of sound and television broadcasting in this country. He also announced that the Government proposes to extend the B.B.C.'s Charter for two years so that it terminates on the same date as the I.T.A.'s—July 29th, 1964.

The Committee's terms of reference are:—

"To consider the future of the broadcasting services in the United Kingdom, the dissemination by wire of broadcasting and other programmes, and the possibility of television for public showing;

"To advise on the services which should in future be provided in the United Kingdom by the B.B.C. and the I.T.A.;

"To recommend whether additional services should be provided by any other organization; and

"To propose what financial and other conditions should apply to the conduct of all these services."

It is also being asked to consider the recent T.A.C. report. The chairman is Sir Harry Pilkington. The last Government committee of inquiry into broadcasting as a whole was set up in 1949 under the chairmanship of Lord Beveridge.

Technical Writing Awards

NEW details have been issued of the scheme introduced ten years ago by the Radio Industry Council for awards to writers of technical articles making known British achievements. The scheme is now sponsored jointly by the Council and the Electronic Engineering Association who award up to six premiums of 25 gn each for what are adjudged the best articles published each year.

The panel of judges now includes:— Air Marshal Sir Raymund Hart (director, R.I.C.), Professor H. E. M. Barlow (University College, London), B. C. Brookes (University College, London), A. H. Cooper (E.M.I.), F. Jeffery (Murphy), G. Reeves (A.E.I.) and Dr. R. C. G. Williams (Philips).

Copies of the leaflet outlining the scheme are obtainable from the secretary, E.E.A., 11 Green Street, London, W.1.

Progress in Medical Electronics

THE publication* of the Proceedings of the Second International Conference on Medical Electronics, Paris, June, 1959, adds a valuable source book to the literature of a rapidly expanding subject. In 614 pages with 400 diagrams and photographs it records more than 80 full papers and 70 abstracts ranging over a wide field and grouped under the several headings of electrophysiological techniques, electroencephalography, cardiology, manometry and flow measurement, acoustic techniques, automation in medicine, radiology and isotopes, and chemical instrumentation.

The editor is C. N. Smyth, M.A., B.Sc(Eng.), B.M., B.Ch., M.I.E.E.

* "Medical Electronics," Iliffe & Sons, Ltd., 145*s*.

Radio Show

THIS year's National Radio and Television Show which opens at Earls Court on August 24th, will follow very much the lines of previous exhibitions and the 130 exhibitors will be showing exclusively British equipment. Audio equipment will again be concentrated in the Audio Hall, which will occupy a large part of the first floor. The Services, Metropolitan Police, G.P.O., B.B.C. and I.T.A. will all have displays, and the organizers are re-introducing in a new form the Television Avenue to show the advantages of the larger screen receivers.

A radio servicing exhibit will serve the treble purpose of showing the public the kind of servicing they should expect, the dealer the latest test equipment available and the would-be apprentice a glimpse of the work of a serviceman.

International Scientific Studies

THE General Assembly of the International Scientific Radio Union (U.R.S.I.), which is held every three years, meets at University College, London, on September 5th. The chief aim of the Union, which was formed in 1919, is "to develop on an international basis scientific studies relating to radio."

The work of the Union is maintained through seven commissions and their "national committee" counterparts in each member country. The commissions are:— I, standards and measurements; II, troposphere; III, ionosphere; IV, radio noise of terrestial origin; V, radio astronomy; VI, radio waves and circuits; VII, radio electronics.

J. A. Ratcliffe, who is to succeed Dr. R. L. Smith-Rose as director of the D.S.I.R. Radio Research Station, is president of the British National Committee. The secretary-general of the Union is E. Herbays, 7, Place Emile Danco, Brussels 18, Belgium.

Hearing-Aid Code of Practice.—Reference was made in our May issue to the proposal of the Joint Advisory Co-ordinating Committee of the National Institute for the Deaf to draw up a code of commercial practice for the hearing-aid industry. This code of practice, which "is designed principally to protect the public against exaggerated or false claims for the efficacy of hearing-aids," has now been approved by the N.I.D. Well over 100 manufacturers and suppliers of hearing-aids are signatories to the code.

Schools TV.—Announcing plans for the extension of its television service for schools for 1960/61, the B.B.C. states that there are now 2,000 schools registered for the transmissions. This number is double that of a year ago.

I.P.R.E.—Founded in 1936 as the Institute of Practical Radio Engineers and in 1951 granted incorporation under the name Incorporated Practical Radio Engineers (I.P.R.E.) Ltd., the association has now changed its title to Incorporated Practitioners in Radio and Electronics (I.P.R.E.) Ltd. The secretary is W. Edwardes, Fairfield House, 20 Fairfield Road, London, N.8.

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Receiving Licences.—The number of combined television and sound licences in the U.K. increased during May by 78,253 bringing the total to 10,646,938. Sound-only licences totalled 4,438,085, including 439,649 for sets fitted in cars. According to a report from Moscow quoted by a German correspondent, there are now 25 million sound receivers in use in the Soviet Union where there also some 28 million loudspeakers connected to local community radio centres and relay networks. The number of television receivers in the Union is given as about four million.

Poldhu.—The site of the first radio station to span the Atlantic (on December 12th, 1901) has been presented by Marconi's W/T Co. to the National Trust. A granite column marks the site of the station, built by Guglielmo Marconi, overlooking Mounts Bay, Poldhu, Cornwall. Among those present at the presentation of the title deeds by Lord Nelson of Stafford was C. S. Franklin, who joined the company in 1899 and whose pioneering work on the Marconi-Franklin beam system was undertaken at the station.

Japan, which employs the 525-line television standard, has officially announced the adoption of the American N.T.S.C. colour system.

Paris Components Show.—The French Fédération Nationale des Industries Électroniques (F.N.I.E.) is to hold the fourth international components show in Paris from February 17th to 21st, 1961.

Semiconductors.—An international symposium on semiconductor devices is being organized by the Société Francaise des Électroniciens et des Radioélectriciens in connection with the components exhibition mentioned above. It will be held in Paris from February 20th to 25th, 1961. Details and registration forms are obtainable from the Société, 10 avenue Pierre-Larousse, Malakoff, Seine, France.

A new aerial system is in course of construction at the Post Office receiving station at Somerton, near Yeovil, Som. When completed 93 new 180-foot masts will be used to support the 65 directional aerial arrays. Work began in May on dismantling 27 of the existing steel lattice masts, many of them 280-feet tall.

T.E.M.A.—At the recent annual general meeting of the Telecommunication Engineering and Manufacturing Association, R. A. Moir, O.B.E., M.C., director of Standard Telephones and Cables, was elected chairman and W. F. Oakley, director of Automatic Telephone and Electric Co., vice-chairman.

Biomedical Electronics.—The 13th annual conference on electrical techniques in medicine and biology, organized by the I.R.E., will be held in Washington, D.C., from October 31st to November 2nd. Further details are obtainable from the Institute of Radio Engineers, 1 East 79th Street, New York 21, N.Y., U.S.A.

Solid-State Circuits.—The 1961 International Solid-State Circuits Conference, sponsored jointly by the I.R.E., the American I.E.E. and the University of Pennsylvania, will be held on February 15th, 16th and 17th in Philadelphia, Pa. The secretary of the organizing committee is F. H. Blecher, Bell Telephone Laboratories, Murray Hill, N.J.

Cybernetics.—The third international congress on cybernetics is being organized by the International Association of Cybernetics (A.I.C.) for September 11th to 15th next year. It will be held in Namur, Belgium. It is planned to have sessions covering semantic machines; technical as well as economic and social aspects of automation; and cybernetics and biology. Further information is obtainable from the A.I.C., 13 Rue Basse-Marcelle, Namur, Belgium.

Electronic Organ Constructors' Society, which now has a membership of some 120, is holding its next meeting at 7.0 on July 28th at the Arsenal Tavern, Blackstock Road, Highbury, London, N.4. Alec Garton, of Nottingham, will be demonstrating his divider organ.

Royal Society Tercentenary celebrations include an exhibition of outstanding achievements in British science during the last ten years. Calculating machines, exploration by radio and electro-physiology are among the many aspects covered. The exhibition is being staged in the Diploma Galleries of the Royal Academy of Arts, Burlington House, Piccadilly, London, W.1, from July 25th to 29th (10.30-6). On the first three days admission is by invitation, but on the last two days the general public will be admitted without tickets.

Automatic Control.—British contributions to the first congress of the International Federation of Automatic Control, recently held in Moscow, will be discussed at a two-day symposium being organized by the Institution of Mechanical Engineers. It will be held on September 27th and 28th at the Institution, 1, Birdcage Walk, London, S.W.1.

Aviation Electronics.—A one-and-a-half-day convention on "Aviation Electronics and its Industrial Applications" is being organized by the South-Western Section of the Brit.I.R.E. for October 7th and 8th. Registration forms and further details of the convention, which will be held in the Bristol College of Science and Technology, are obtainable from the Hon. Sec., South-Western Section, Brit.I.R.E., c/o The School of Management Studies, Unity Street, Bristol, 1.

An Electro-Acoustics Group has been formed by the Brit.I.R.E., and its inaugural meeting will be held on October 12th, when Professor Colin Cherry, of Imperial College, will be the speaker.

Northern Polytechnic.—An evening course of 24 lectures on colour television is again included in the 1960/61 prospectus of the Northern Polytechnic, Holloway, London, N.7. The scope of the Department of Telecommunications, of which John C. Gilbert is head, has been broadened considerably and includes full-time, part-time and evening courses in industrial and applied electronics, computers, microwaves and navigational systems.

Printed Circuit Techniques.—A course of thirteen weekly lectures covering the preparation and production of printed circuits begins at the Twickenham Technical College, Egerton Road, Twickenham, Middx., on Tuesday evening, September 20th. Fee 30s.

Brentford Evening Institute, Clifden Road, Brentford, Middx., is again holding courses during the coming session in radio servicing (on Tuesdays and Thursdays) and on Wednesdays a course in preparation for the Radio Amateur Examination. Classes commence on September 20th (fee 10s per term).

Transistor Techniques.—The Medway College of Technology, Chatham, Kent, is again providing a course of lectures and experimental work on transistor techniques on successive Tuesdays, commencing October 4th.

Northwood Evening Institute, Potter Street, Northwood, Middx., is organizing classes in radio theory and also for the Radio Amateur Examination for the coming session which begins on September 19th.

WHAT THEY SAY

Now We Know Why!—"The decision to build your own high-fidelity instrument is the beginning of an emotional adventure. . . . Every time a man turns a knob or plays a record, there is an unparalled intimacy between himself and the instrument . . . and the sound." —Sidney Harman, of Harman-Kardon, New York.

Stimulating.—" . . . and it may be the reason that some hi-fi fans like to play their systems at loud volumes —for body stimulation." From "Perception of the stereophonic effect as a function of frequency," by W. B. Beambien and H. B. Moore, *Journal of the Audio Engineering Society*, April, 1960.

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Personalities

Earl Mountbatten of Burma has been appointed honorary member of the Armed Forces Communications and Electronics Association. The certificate of membership "in recognition of his long-standing personal interest in defence communications" was presented to him at the Ministry of Defence by Major-General Harold Grant, a vice-president of the Association. The A.F.C.E.A. is an American organization (of which there is a chapter in London) and Lord Mountbatten is only the second Englishman to receive honorary membership, the first being **Brigadier W. T. Howe**, O.B.E., secretary of the Royal Signals Institute.

N. A. de Bruyne, M.A., Ph.D., F.Inst.P., is resigning from the managing directorship of CIBA (A.R.L.), Ltd., at the end of the year to give more time to research. He remains on the board and **R. F. G. Lea**, O.B.E., M.A., and **D. A. Hubbard** will become joint managing directors. Dr. de Bruyne founded in 1934 the original company (Aero Research Ltd., of Duxford) which was acquired in 1947 by CIBA, of Basle, and the name changed to its present title two years ago. Dr. de Bruyne was formerly fellow and lecturer of Trinity College, Cambridge. In 1952 he contributed an article to *Wireless World* on the uses of a Fresnel lens for the magnification of television pictures.

Eric D. Daniel, M.A. (Oxon.), A.M.I.E.E., has been appointed head of the new research unit set up by Ampex Electronics Ltd. at Reading, Berks. He did two years' research work in audiometers and general electro-acoustics at the Post Office Research Station before joining the B.B.C.'s Research Department in 1946 where, in association with **Dr. Peter Axon**, now managing director of Ampex, he specialized in magnetic tape recording. Mr. Daniel left the B.B.C. in 1956 and has spent the last four years in America.

E. D. Daniel

P. E. M. Sharp

Peter E. M. Sharp, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E., has joined Westrex Co. as general manager. For the past two or three years he has been personal assistant to the managing director of the Troughton and Young group of companies. Previously he was with the Telegraph Construction and Maintenance Co. and was for some time with their agents in the Far East. In 1959 Mr. Sharp was awarded a Ford Foundation Grant by the English-Speaking Union for a two months' tour of the United States.

L. J. Kennard, A.M.I.E.E., has joined the Microcell group of companies as head of the data handling and process control section of the group's Electronics Division. Immediately prior to joining Microcell he was with Solartron where he was concerned with radar simulators and industrial controls.

Sir Gordon Radley, K.C.B., C.B.E., Ph.D., M.I.E.E., who retired from the director-generalship of the Post Office in May, is to devote part of his time to the work of the English Electric group of companies, particularly the development of telecommunication equipment. He has also been elected a director of Marconi's W/T, Marconi Instruments and English Electric Valve Co. and has been elected to the board of Marconi Marine.

J. M. Westhead, B.A., Ph.D., has been appointed manager of the valve and semiconductor sales department of the A.E.I. Electronic Apparatus Division at Lincoln. He has been deputy manager of the department since April, and succeeds **F. Baxendale** who is continuing as consultant. Dr. Westhead studied at Oxford University where in 1950 he graduated with first class honours in physics. Two years later, while a University demonstrator in electronics, he gained his doctorate in nuclear physics. In 1956 he joined B.T.H. now part of A.E.I.

Dr. J. D. McGee, O.B.E., M.Sc., M.I.E.E., professor of instrument technology, Imperial College of Science and Technology, London, has been awarded a grant of £1,000 by the Paul Instrument Fund Committee for the construction of a television system for X-ray image intensification. This award is supplementary to a previous grant of £2,000.

OUR AUTHORS

L. H. Dawson, B.Sc., author of the article on page 381, has been with Marconi's W/T Co. for nearly 22 years, and is at present in the mobile navigational aids research division at the company's laboratories at Great Baddow. In 1957 he headed the development team working on the "Consort" marine radar, and more recently was associated with the development of the company's traffic analyser, colloquially known as "Police Radar."

R. V. Harvey, B.Sc., A.M.I.E.E., the first part of whose article describing a transistor v.h.f./f.m. receiver appears in this issue, studied electrical engineering at Faraday House, where he obtained the diploma. In 1943 he joined the receiver group of the Telecommunications Research Establishment (now R.R.E.), Malvern, leaving there in 1947 to study physics at King's College, London. Since graduating in 1950 he has been in the B.B.C. Research Department.

R. B. Rowson, B.Sc., A.M.I.E.E., joint author of the article on an inverted triode voltmeter, is assistant chief commercial engineer (research and statistics) with the South Wales Electricity Board, and was previously personal assistant to the chief engineer, British Power and Light Corporation. **A. P. Williams**, A.M.I.E.E., his co-author, is senior assistant engineer in the system operation department at the Board's headquarters, where he is responsible for line telephony, remote control and v.h.f. radio equipment.

OBITUARY

Horace de Aula Donisthorpe, affectionately known throughout the radio industry as "Donny," died suddenly on June 15th. Born in 1893 and educated at the City and Guilds College, he joined Marconi's as a marine radio operator and was later engaged under H. J. Round on the development of valves. After service in the Intelligence Corps during the First World War he rejoined Marconi's and in 1922 was appointed assistant to the general manager. From 1926 until his retirement last year he was with the G.E.C., latterly as deputy manager of the Valve and Electronics Department. For the past year he had been sales consultant to Whiteley Electrical Radio Co. Donisthorpe was a prime mover in the formation of the Radio Industries Club, of which he was chairman for eleven years prior to being elected president for the year 1948/49.

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News from the Industry

Choiceview is the name under which the Rank Organisation and Rediffusion will operate a partnership "for the development and promotion of subscription television . . . and for providing relevant programme and technical services." The two companies entered into a long-term agreement some months ago whereby the Rank Organisation acquired the right to use the Rediffusion system of wired television in relay operations. It is announced that the Choiceview system of "Pay TV" will be available in due course for general licensing to intending operators.

Instruments Merger.—The Cambridge Instrument Company has acquired the whole of the ordinary share capital of Electronic Instruments Ltd., of Richmond, Surrey. The merger was announced on June 29th by Dr. P. Dunsheath, chairman of Cambridge Instruments which, with its overseas subsidiaries employs over 1,500 people. Electronic Instruments, which employs some 330 people, will operate under its own name and A. C. W. Norman will continue as chairman, P. Goudime as managing director and D. A. Pitman as sales director together with three directors of the Cambridge Instrument Co. Mr. Goudime has been invited to join the board of the Cambridge Instrument Co.

Dawe Instruments Ltd. and its associated company, L.M.K. Manufacturing, have been acquired by Simms Motor and Electronics Corporation. The acquisition "for a sum in the region of £250,000" extends still further the electronics side of the Simms Group which was recently augmented by the acquisition of Cawkell Research and Electronics. The reconstituted board of Dawe Instruments now consists of G. E. Liardet, chairman (chairman and managing director of the group), and F. W. Dawe, managing director, together with J. Ayres, M. A. Hassid and K. G. Smith, members of the boards of Cawkell and N.S.F.

Greencoat Electronics Ltd. is the new title of Staar Electronics Ltd., of 2 Princes Row, Buckingham Palace Road, London, S.W.1 (Tel.: Tate Gallery 9393). The company, which is a member of the Gas Purification Group, will continue to market the "Little Staar" 45 r.p.m. battery-operated motor and the range of Kinder d.c. motors. Very substantial quantities of these miniature motors are being exported to Germany. The company's sales director is Harry Read.

Harry Read

Derritron Group, of which V. G. P. Weake is chairman and managing director, announces that C. T. Chapman (Reproducers) Ltd., of High Wycombe, Bucks., has joined the group. The company will in future be known as Chapman Ultrasonics Ltd. C. T. Chapman remains managing director and is joined on the board by V. G. P. Weake and R. A. W. Rudd. Doran Instrument Co., of Stroud, has also joined the group. W. E. Doran remains managing director with Mr. Weake (chairman) and Capt. J. D. Mansfield-Robinson also on the board.

Elizabethan (Tape Recorders) Ltd., is the new name adopted by E.A.P. (Tape Recorders) Ltd. of Bridge Close, Oldchurch Road, Romford, Essex (Tel.: Romford 62366).

L.C.E. Ltd. is the name of a recently formed company jointly owned by Joseph Lucas (Industries), Ltd. (through its subsidiary G. & E. Bradley, Ltd.) and the Collins Radio Co., of America. Lord Halsbury, the chairman of L.C.E., stated that although this is an Anglo-American partnership, the company is a completely autonomous body. It is not tied to a sole policy of manufacturing Collins equipment. Collins Radio have a marketing company in this country but until now had no manufacturing facilities in Europe. L.C.E., Ltd., is operating from Electral House, Neasden Lane, London, N.W.10, and it is planned to have a factory in operation by September.

T.C.C.-Sprague Agreement.—Under an agreement between the Telegraph Condenser Co. of this country and Sprague Electric Co. of the U.S.A., T.C.C. acquire the right to all Sprague U.K. patents and applications, together with the technical and engineering information necessary to exploit them, and Sprague will make available to T.C.C. all its present research and technical information and engineering knowledge. Also "for the next 21 years the two companies will exchange research, development and manufacturing knowledge, extending beyond the field of capacitors and embracing all the products of the two companies."

Standard Telephones and Cables have supplied all the submarine cable and 29 submerged repeaters for the 530-nautical-mile route across the North Sea for the first direct telephone cable link between the U.K. and Sweden. It is the longest submarine telephone cable system in Europe and is also the longest in the world using a single cable for both directions of transmission. The repeaters are designed to carry 60 telephone circuits of 4kc/s spacing. The cable is now being laid between Middlesbrough and Gothenburg by the G.P.O. cable ships *Monarch* and *Ariel*.

Anglo-French Agreement.—Steatite and Porcelain Products, of Stourport-on-Severn, have concluded an agreement with Compagnie Générale d'Electro-Céramique "for full technical collaboration including exchange of patent rights." Each company will act as agents in its own country for the other manufacturer.

Eimac Agents.—Walmore Electronics Ltd., of Phœnix House, 19-23 Oxford Street, London, W.1, have been appointed exclusive representatives in the U.K. for all products of Eitel-McCullough, Inc., of San Carlos, California.

Eitel-McCullough, S.A., has been set up in Geneva, Switzerland, as a European marketing organization by Eitel-McCullough.

Ether Langham Thompson (Italiana) Ltd., with offices and factory at Via Bisleri 19, Milan, has been formed by Ether Langham Thompson Ltd. to market and manufacture products of the group. The board of directors of the new Italian company includes J. Langham Thompson (chairman), F. W. Coulling and F. B. Duncan, who are directors of the parent company.

Campbell-Bruce Electronics Ltd. has been formed for the development of small transistor communications equipment. Offices and laboratories are at 22 Berners Street, London, W.1. (Tel.: Langham 7878.) The directors are I. Campbell-Bruce (managing), who was sales director of Cossor Communications Co.; M. D. S. Becher and R. Howard.

Teppaz record players, which are manufactured in Lyons, France, are now being handled in this country by Selecta Gramophones Ltd., of which E. R. Lewis (chairman of the Decca Record Co.) is chairman.

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Westward Television Ltd., programme contractors for the I.T.A. south-west England transmitters to be built in Devon and Cornwall, have placed the main contract for the electronic equipment for their Plymouth studios with Marconi's. They will supply five Mark IV image Orthicon camera channels, master control and monitoring equipment and associated sound channels. E.M.I. are supplying two Vidicon film scanners, Rank-Cintel one film scanner and Pye a caption scanner.

An Emidec 1100 all-transistor computer has been ordered from E.M.I. Electronics for the Royal Naval Store Depot, at Copenacre, Wilts. It will handle the stock control of some 90,000 separate items covering the electrical, radio and asdic stores for H.M. ships.

An Orion electronic digital computer has been ordered from Ferranti Ltd. by the National Institute for Research in Nuclear Science. The computer will be installed at the Institute's Rutherford High Energy Laboratory at Harwell, Berkshire. Equipped with magnetic tape units and high-speed printers, Orion will be used by the laboratory for analysis and computation of data obtained from NIMROD, the 7GeV proton synchroton now under construction at Harwell.

Murphy.—The 1959 profit of the Murphy group before taxation was £668,085, an increase of almost 50% on the previous year. The net profit after taxation was £358,442 compared with £207,724 the year before.

Ever Ready Co. (G.B.) record a profit before taxation of £2,735,128 for the year ended in February, compared with £2,430,553 the previous year. Taxation for the period is estimated at £1,184,146.

Elliott-Automation Group.—The group profit before taxation of £1,015,630 for 1959 represented an increase of about 25% over the previous year. Taxation absorbed £466,755.

Ferranti accounts for the year ended March 31st show a group profit of £2,123,390, which was almost twice the previous year's figure. This was after deducting all charges, including £1,854,000 for taxation.

S.T.C. installed the sound reinforcement system in the new Royalty Theatre built on the site of the Stoll Theatre, Kingsway, London. The installation includes 19 amplifiers, 12 microphones and 41 loudspeakers. S.T.C. have also supplied the sound equipment for the *son et lumière* installation for H.M.S. *Victory* at Portsmouth.

"Hi-Fi" Catalogue.—An unusually well-prepared catalogue of "hi-fi" recording and reproducing equipment has been issued by Lasky's (Harrow Road) Ltd., 207 Edgware Road, London, W.2. Printed on art paper and profusely illustrated it gives manufacturers' particulars of all the leading makes retailed by the firm, with the object of facilitating the choice of equipment. It comprises 72 pages and costs 3s 6d to callers or 4s by post.

Temporary Address.—Wright & Weaire, the Ferrograph Co. and British Ferrograph Recorder Co. have temporarily moved to 88 Horseferry Road, London, S.W.1 (Tel.: Sullivan 5426), pending completion of new offices in Cromwell Road, Kensington, next year.

Teleng Ltd., manufacturers of communal aerial systems and relay equipment, are building a two-storey extension to their factory at Harold Wood, Essex. It will increase the available floor space from 6,000 to 17,000 sq. ft.

G.E.C. Applied Electronics Laboratories have been transferred from Brown's Lane, Coventry, to The Airport, Portsmouth, Hants. (Tel.: Portsmouth 62271.)

Oryx Electrical Laboratories Ltd., manufacturers of Oryx soldering irons, have moved to Industrial Estate, Meadow Road, Worthing, Sussex (Tel.: Worthing 30066).

EXPORT NEWS

Travelling wave tubes manufactured by the English Electric Valve Co. have been supplied to the Bonn University for its radiotelescope which is to be used for investigating the temperature of interstellar gas. Special dual channel amplifying equipment, using two tubes in cascade in each channel, has been supplied to the University by Marconi's. The telescope's parabola is 83-ft in diameter.

Aeronautical Communications.—International Aeradio Ltd., in conjunction with Pye Telecommunications, Ericsson Telephones and Creed & Co., installed the equipment for the inter-island multi-channel aeronautical radio communications system which links the eastern islands of the West Indies. It provides a 24-hour automatic telephone and teleprinter service for aircraft operating in the Caribbean. Twelve separate and simultaneous voice channels together with 12 to 18 teleprinter channels have been provided.

Surveillance Radar.—Two 50-kW, 50-cm radars, together with three display consoles and ancillary equipment, have been ordered from Marconi's for Momona Airport, Dunedin, New Zealand.

Airfield Radar.—A contract has been awarded to Decca Radar by the Crown Agents for the supply to the Royal Ceylon Air Force of a Decca 424 Mark II airfield control radar. It is to be installed at Katunayake, an Air Force Base which is also used by civil airlines operating scheduled flights.

Radar Weather Stations.—Cossor Radar & Electronics are to supply "windfinding radars" (Type CR353) for the network of eight radar weather stations to be set up in the South Pacific. Six stations will be in New Zealand, one in Fiji and another on Funafuti Island.

Electronic Development in Great Britain is the theme suggested for the prestige trade exhibition to be staged in the British Pavilion at the German Industrial Exhibition in Berlin from September 10th to 25th. Information is obtainable from the Central Office of Information, Hercules Road, London, S.E.1.

Mobile demonstration unit of E.M.I. which undertook a 4,000-mile tour of Western Europe last autumn, is now visiting Eastern Europe. The 35-ft trailer is fitted with machine tool control systems, closed-circuit television and other industrial electronic equipment.

SEPTEMBER ISSUE

Show Guide

The next issue of *Wireless World*, appearing a day or two before the opening of the 27th National Radio and Television Exhibition at Earls Court (Aug. 24th-Sept. 3rd), will contain a stand-to-stand guide to the show together with a plan and list of exhibitors.

The September issue will also include constructional details of the v.h.f./f.m. transistor receiver outlined by R. V. Harvey on p. 366 of this issue. The enlarged September number will also contain the usual quota of articles and regular features.

OCTOBER ISSUE

Show Review

The year's trends in vision and sound broadcasting receivers as exemplified by the equipment seen at Earls Court will be reviewed in the October issue. It will also include a survey of aviation radio gear seen at the Farnborough Air Show (Sept. 5th-11th).

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Battery-Powered Marine Radar

DESIGN OF TRANSISTOR POWER SUPPLY FOR SMALL-CRAFT EQUIPMENT

By L. H. DAWSON,* B.Sc. (Eng.)

MARINE radars have, in the past, been developed mainly for use on the larger passenger and cargo ships where size, weight and power consumption are not of primary concern. However, the "Consort"† radar has been designed to be suitable for shipping such as tugs, fishing boats, pilot cutters, police and customs launches and private yachts.

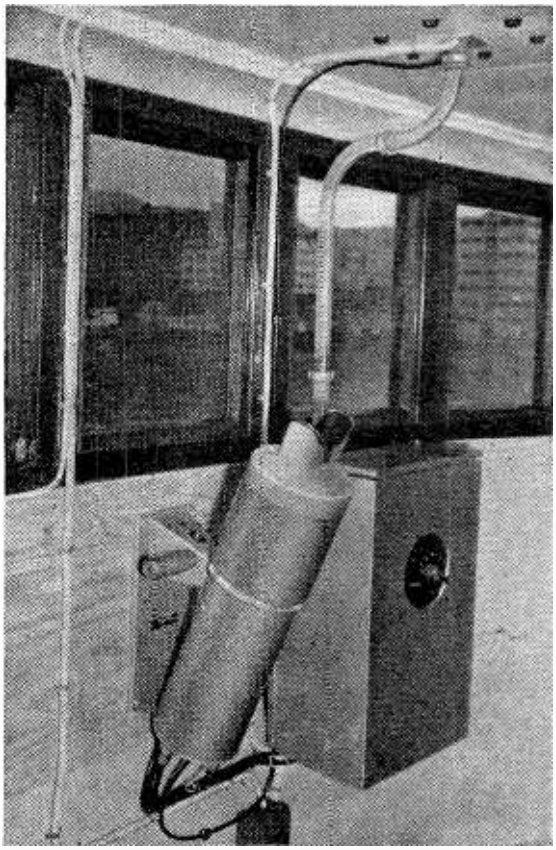
In these smaller vessels the main, and usually the only, source of electrical power is a 24-volt battery which is used to supply the ship's lighting and radio equipment. It is recharged by an engine-driven dynamo and may also serve as the starter battery for the ship's engines. Standard radars may require upwards of one kilowatt of power; but the "Consort" requires much less than this, taking only nine amps from the 24-volt battery in full operation and four amps on "standby." A "press-to-view" switch is fitted to the "Consort." The equipment automatically reverts to the "standby" condition at the end of the two-minute viewing period, but is immediately ready for a further period of operation.

To achieve consumption as low as 220W some special techniques have been used in the design and only the essentials of a radar have been included. The consumption might have been reduced even further by extensive use of transistors instead of valves; but this would have been contrary to another main aim of the design, which was to keep the cost low. Thus transistors were used in the power supply, where they offer the greatest advantage over more conventional equipment, both in cost and efficiency.

Transistor Stabilizer

As is well known, the e.m.f. of a lead-acid battery varies with its state of charge. A single cell terminates its charge at 2.66 volts and is considered to be fully discharged at 1.8 volts. Thus the e.m.f. of a nominal 24-volt battery can vary over the range of 32 to 21.6 volts. Electronic equipment cannot normally tolerate such a large variation in its supply, so some form of automatic stabilization is necessary.

Until quite recently there have been only two practical methods of doing this. One was to use a "carbon-pile regulator" and the other was to employ a motor-driven rheostat controlled by some form of error-sensing circuit. There are disadvantages in both these methods. The carbon-pile regulator can need frequent attention due to gradual softening of the carbon discs during use. A regulator large enough for the "Consort" equipment would consume about 10 watts in its control circuit and could not follow input variations faster than a few cycles per second. The motor-driven rheostat is even slower in operation and if sudden changes of load current are to be accommodated, some auxiliary switching is necessary.



"Consort" radar in wheel-house of the Norwegian ferry "Sunnmore." Display on left, transmitter-receiver, timebase and power-supply unit on right.

Within the last two or three years, high-power transistors have become available and these can be used as the series element of a stabilizer which, in general principle, is similar to a conventional h.t. stabilizer using valves. This is possible because power transistors can pass several amperes with only a fraction of a volt between collector and emitter.

In the "Consort" radar, the maximum load current that has to be stabilized is eight amps and transistors exist that can handle this and even greater currents. However, the choice does not rest on current-carrying capabilities alone: cooling is necessary, as the maximum junction temperature must be limited to, say, 85 to 90°C.

The level at which the output of the stabilizer is controlled should be as high as possible (con-

* Marconi's W.T. Co., Ltd.
† Marconi International Marine Communication Co., Ltd.

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sistent with being lower than the lowest battery p.d.) in order to keep down the power dissipation in the series transistors. The level should also be suitable for direct connection to a valve-heater chain so that inefficiencies of conversion may be avoided. To satisfy these two requirements 19 volts has been chosen as being nearly equal to 3×6.3 volts, i.e., three times the standard heater p.d. In the "Consort" power supply the stabilizer must operate over a range of load currents from four amps minimum to eight amps maximum, while the voltage drop may be as much as 32-19=13 volts. The definite minimum current allows the use of a by-pass resistor to reduce dissipation in the series transistors and this resistor can have a value as low as 13/4 ohms. The standard value of 3.3 ohms is suitable.

It can be shown that the maximum dissipation in the series transistor occurs when the load current is shared equally between the transistor and the by-pass resistor, provided other design limits are not exceeded. In this case, with eight amps load current, the maximum transistor dissipation is $(8/2)^2 \times 3.3 = 53$ watts approximately, corresponding to a battery p.d. of 32 volts. If the equipment is to work in ambient temperatures up to 55°C and the maximum junction temperature is, say, 90°C, the permissible temperature rise is only 35°C. This means that the effective overall thermal resistance between the junction and surrounding air must not be greater than 35/53, i.e., 0.66°C/W. No transistors are as yet available with such a low thermal resistance, even between the junction and mounting base; therefore more than one transistor must be used to share the power loss.

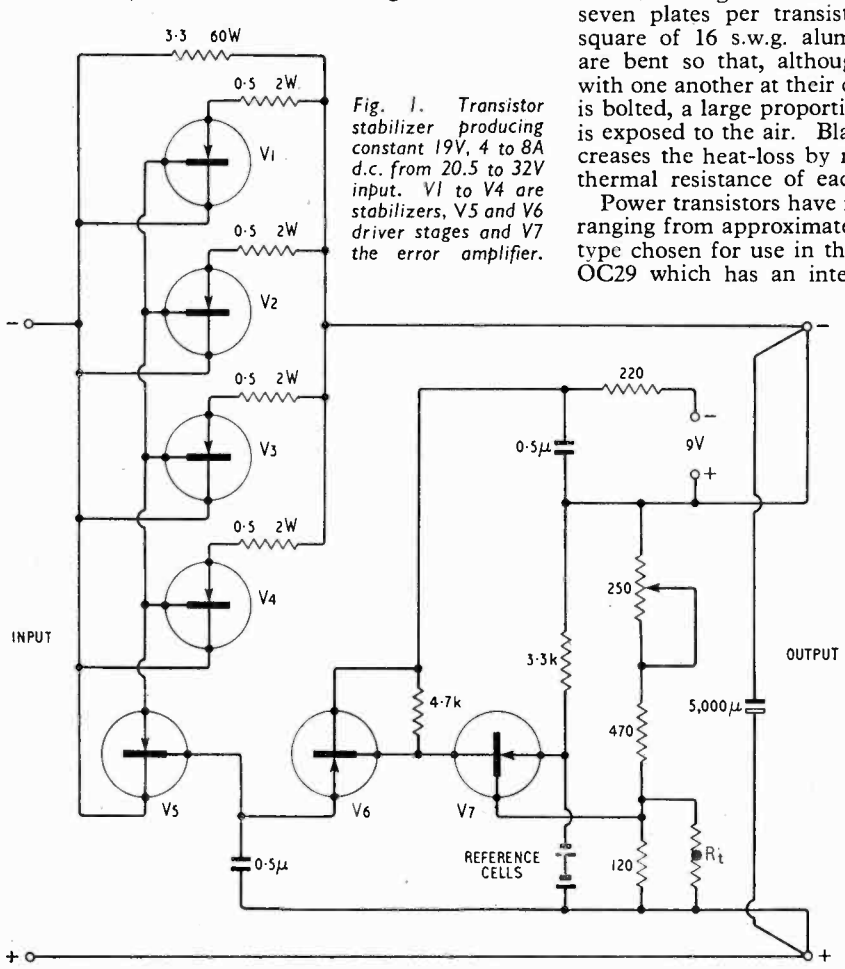

Fig. 1. Transistor stabilizer producing constant 19V, 4 to 8A d.c. from 20.5 to 32V input. V1 to V4 are stabilizers, V5 and V6 driver stages and V7 the error amplifier.

Cooling Methods

The next consideration is, how should the heat be removed from the transistor-mounting bases? The almost obvious answer for a marine radar is to use the sea water for cooling. This, however, means a pump, long pipes and a filter. If any of these failed to work satisfactorily, the transistors would soon be irreparably damaged, with a possibility of further damage to the rest of the equipment. A second method would be to blow air over them but, here again, a filter would be needed. Furthermore, a small d.c.-operated blower is not normally a very quiet device and does not have a very long life.

The most reliable method is to use large-area cooling fins, and to provide adequate ventilation. The fins will dissipate the heat by a combination of convection and radiation; but to do this efficiently they must make good thermal contact with the transistors and be of high thermal conductivity with short paths from the transistors to the edges of the fins.

The cooling fins used in the "Consort" consist of seven plates per transistor, each plate being 6-in square of 16 s.w.g. aluminium sheet. The plates are bent so that, although they are all in contact with one another at their centres where the transistor is bolted, a large proportion of the total surface area is exposed to the air. Blackening of the surfaces increases the heat-loss by radiation, and the resulting thermal resistance of each set of fins is 1.5°C/W.

Power transistors have internal thermal resistances ranging from approximately 0.8°C/W upwards. The type chosen for use in this stabilizer is the Mullard OC29 which has an internal thermal resistance of 1.2°C/W—nearly as good as and considerably cheaper than the best available. This makes the overall resistance 2.7°C/W so that four units in parallel give an effective value of 0.675 °C/W—very close to the required value—and an estimated temperature rise of 35.8°C at maximum dissipation. This is considered a sufficiently conservative design for three reasons:—

1. Although the recommended maximum temperature for the OC29 is 90°C, temperatures up to 100°C are permissible for short periods (provided total time at this temperature does not exceed 200 hours).

2. The maximum dissipation requires a battery at 32V or 2.66V/cell.

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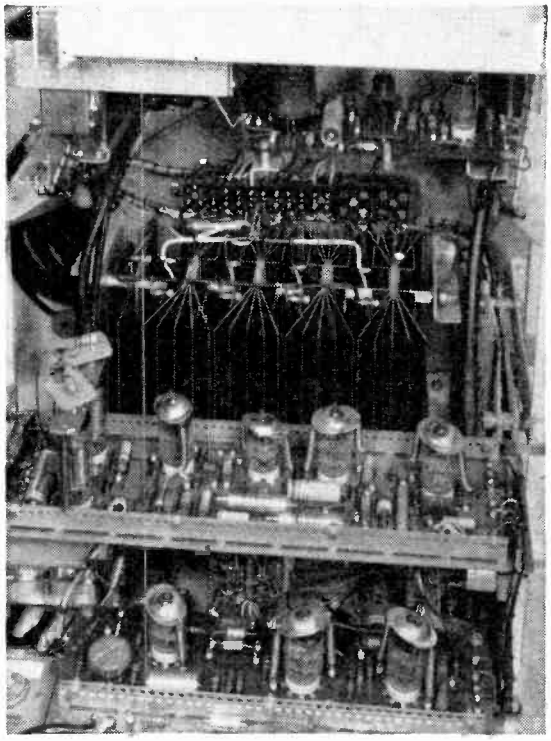

View of stabilizer power transistors, showing way in which cooling fins are splayed outwards from centre, where transistor is fitted to increase surface area.

This is very high and unlikely to be maintained for more than a few minutes or even reached in hot weather.

3. The stabilizer heat sink (cooling fins) has a fairly high thermal capacity and takes about one hour to reach a steady temperature.

This last factor is of great importance when considered in conjunction with the "two-minute viewing" feature of the equipment.

Circuit Design

Having obtained a satisfactory design for a heat sink, the electrical design can be proceeded with (Fig. 1). A small resistor is connected in each power-transistor (V1 to V4) emitter lead to provide a degree of current feedback which equalizes the emitter-current base-potential characteristics and causes the four transistors to carry similar currents. The 3.3Ω, 60-W resistor is the by-pass. With this combination of four transistors carrying a total of eight amps maximum, the base current requirements are quite large. To reduce the control current to a low level a tandem pair of emitter-followers, V5 and V6, are used. The dissipation in V5 can amount to as much as 2W, so a power transistor is necessary. To keep the number of different types to a minimum (and therefore the spares requirements low) V5 is another OC29. The heat sink requirements for this transistor are very modest and a single cooling fin of the same size as those in the main assembly is more than sufficient. The overall current gain is approximately the product of the three current amplification factors of V1, V5 and V6, amounting to some 75,000 times. This makes the normal base-current requirements of V6 only about 0.2mA, supplied via the 4.7kΩ collector load of V7, the error amplifier.

This collector load resistor and the collector of V6 are connected to an auxiliary nine-volt supply to avoid increasing the minimum potential drop in the stabilizer. Without this auxiliary supply the minimum working potential would have been increased by the base-to-emitter p.d. of both V5 and V6 as well as the potential drop in V7 collector load. In the system as shown, the minimum potential drop in the stabilizer is the sum of the p.d. across one 0.5-Ω sharing resistor, the base-to-emitter p.d. of V1 2, 3 or 4 and the collector-to-emitter potential of V5, amounting to about 1.5V total. The lowest input potential at which the output can be stabilized to 19 volts is therefore 20.5 volts, so allowing for one volt drop on the battery leads.

The error amplifier V7 has its emitter potential fixed by a pair of reference cells. These are small hermetically-sealed units designed to provide a constant 1.5-V p.d. with a low dynamic impedance. They have very little storage capacity and must be supplied with a charging current; they are therefore similar in operation to neon stabilizer tubes and Zener diodes. Neon tubes are, naturally, not suitable and Zener diodes are many times more costly.

A divider chain of low resistance compared with the input impedance of V7 applies a fraction of the output voltage to the base of V7. A thermistor R_t is arranged so as to compensate for the temperature characteristics of both V7 and the reference cells. The 5000-μF capacitor connected across the output provides a low impedance at a.c. and the 0.5-μF capacitor connected from the base of V5 to the common positive line suppresses any tendency to oscillation.

The output impedance of the stabilizer at d.c. and very low frequencies can be calculated as $1/ABg_m$ where A is the current gain from V6 base to V1-4 emitters, B is the voltage ratio of the divider chain and g_m is the slope of V7 expressed in collector current (A)/base potential change (V). This comes to $1/75{,}000 \times 0.17 \times 0.05 \approx 0.002\Omega$. At higher frequencies the current amplification factors of all the transistors fall off and the output impedance increases to a value set mainly by the series resistance of the 5000-μF electrolytic capacitor, which is of the order of 0.05Ω. To achieve these low values of resistance care has to be taken with the lengths and disposition of connecting leads. For instance, it is necessary to take separate leads direct from the

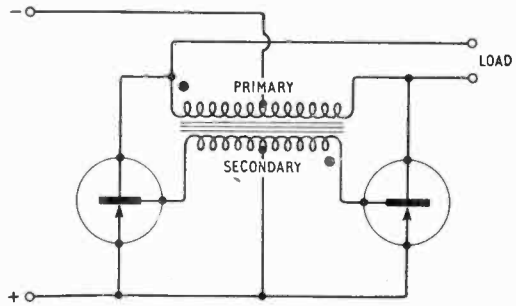

Fig. 2. Basic oscillator for "chopping" d.c. to produce a.c. Dots on transformer denote start of windings.

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error amplifier to the output terminals, as in Fig. 1.

The collector impedance of the series transistors is high (hundreds of ohms) so that the stabilization ratio of the circuit is simply the ratio of the by-pass resistance to the output impedance and is in the order of 1,000 times. This is a very satisfactory figure and means that the "Consort" radar can be operated from nominal 24-volt d.c. supplies having a large amount of ripple superimposed, so long as that ripple does not take the input voltage outside the design limits of the stabilizer, i.e., 20.5 to 32 volts.

D.C. to A.C. Converter

Several different h.t. potentials are required in the "Consort" radar equipment, as well as separate supplies for both the magnetron and klystron heaters and the nine-volt auxiliary supply for the stabilizer. To obtain these it is necessary to convert the stabilized 19-volt d.c. to some form of a.c. The

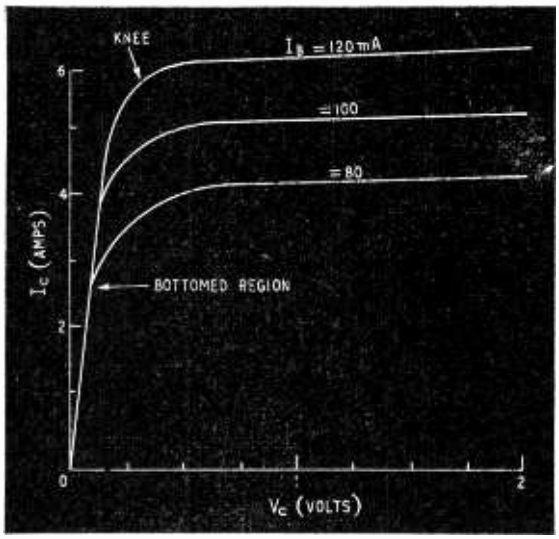

Fig. 3. Typical collector potential/collector current characteristics of power transistor.

traditional methods have been to use either a rotary machine or a vibrator. The former is expensive and heavy, while the latter has a very short life. Now that power transistors are available, a third method is possible.

Again the ability of transistors, when "bottomed", to pass large current with a very low potential drop between collector and emitter is used: the "saturation resistance" is measured in hundredths of an ohm. They can thus replace the mechanical contacts of a vibrator, the switching action being controlled by a drive waveform applied to the bases. The base drive is conveniently obtained by transformer action from the output so that the circuit resembles a push-pull oscillator, as shown in Fig. 2.

Mode of Operation.—The characteristics of the transformer have a major controlling influence on the oscillation frequency. During one half cycle practically the whole of the supply potential is applied to one half of the primary winding. The potential is opposed by the induced e.m.f. in the transformer winding so that the rate of change of flux is substantially constant. A magnetizing current is necessary to produce the flux and when the transformer core begins to be saturated, this magnetizing current increases rapidly.

The conducting transistor has been maintained bottomed by the drive applied to its base via the secondary winding on the transformer. This drive potential can produce only a limited base current which in turn sets the maximum collector current the transistor will pass. When the sum of the load current and the magnetizing current approaches this value (and it does so rapidly as the core saturates) the operating point on the current collector potential characteristic moves from the bottomed region round the knee (see Fig. 3). The collector potential increases: as a consequence the transformer primary potential must decrease and this in turn reduces the drive to the base. The available collector current is thereby reduced causing the operating point to move even farther round the knee. The whole effect is cumulative, causing a rapid switch-off of the transistor. The stored energy in the magnetic circuit causes the transformer output to "overswing" sufficiently to switch on the other transistor and start the next half cycle.

During each half cycle the core swings from saturation in one direction to saturation in the other direction and hence it can be shown that the frequency of oscillation is given by:—

$$f \approx V.10^4/4NAB_{sat}$$

where V is the supply potential in volts, N is the number of turns on each half of the primary, A is the effective cross-sectional area of the core and B_{sat} is the maximum flux density achievable in the core.

The simple circuit shown in Fig. 2 has one defect —it will not start under load. It may not even start without a load unless the transformer losses are very low. This is because the transistors pass only very small currents if the bases are at emitter potential. To make the oscillator start under all normal-load conditions a sufficient forward bias must be provided and this can be done conveniently by a potentiometer network across the supply, as in Fig. 4. The transformer secondary potential must be increased to compensate for the potential drop due to the base current flowing in R_2.

This explanation of the mechanism of switch-over between the two transistors is rather over-simplified, although convenient. A more accurate explanation is that as the transistor operating point moves up the I_c-V_c curve, such as shown in Fig. 3, the slope of the curve decreases, i.e., the dynamic impedance of the collector increases. This means that the instantaneous loop gain increases until, at unity loop gain, a point of unstable equilibrium is reached. The switch-over action then takes place rapidly.

Looking at the simple arrangement of Fig. 2 in this light it can be seen that switch-over may well occur at collector-current levels which are much less than those allowed by the base currents. This is especially true with high impedance loads, i.e., light loads on an oscillator fed from a high-p.d. d.c. source. To correct this condition the loop gain must be reduced and, strange though it may seem, this can be done by increasing the amplitude of the drive waveform from the transformer secondary and absorbing the excess in a series base resistance.

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That this is so can be seen by taking extreme cases, as in Fig. 5. The curve represents a typical V_b-I_b characteristic with the required operating point marked A. With a zero-impedance base circuit a 10% reduction of base potential brings the operating point to B, while if an infinite impedance could be used, the operating point would be moved only to C, a considerably smaller change of base current.

The resistance obviously cannot be infinite, and indeed cannot be very large if excessive waste of power is not to occur. It need, however, only be high compared with the input impedance of the base itself, which, in transistors of this class, is only one or two ohms. A satisfactory value is 10 ohms and this is the value chosen for R_2 in Fig. 4. A separate resistor for each base is not necessary, as R_2 serves for each alternately.

Transformer Details

These principles of design have been used for the d.c.-to-a.c. converter of the "Consort" radar. A pair of OC29s switching at 6 amps handle an input current of 4.75 amps from the stabilized 19-volt supply. The frequency of oscillation is 2 kc/s and a Ferroxcube-cored transformer supplies the drive to the bases as in Fig. 4. On light loads most of the stored energy in this core is returned to the supply via the collector-emitter path of the transistor. While this energy is being removed the collector and emitter interchange roles. The transistor resistance this way round is relatively high so that excessive stored energy would cause a large "spike" on the leading edge of the square-wave output waveform. For this reason the core is chosen to be as small as possible. Leakage inductance between the two half-primaries is also a cause of spikes on the waveform, and this, too, must be kept as small as possible in any load-coupling transformers as well as in the maintaining transformer. This is accomplished by winding the primary in bifilar fashion, i.e., two wires are laid side by side and wound together to form the two half-primaries.

One of the advantages of a high oscillator frequency is that the load transformers can be small. In the h.t. systems the smoothing components may also be reduced in size. As the output waveform is essentially a flat-topped square wave, a full-wave rectifier system can supply the load directly—a reservoir capacitor is needed only to supply the load during the transitions of the square wave and no further smoothing is required.

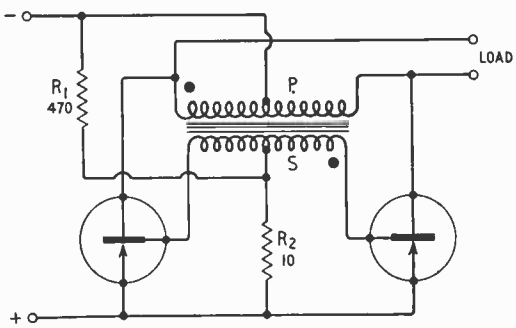

Fig. 4. Final oscillator for production of h.t. and special l.t. Resistors R1 and R2 aid starting.

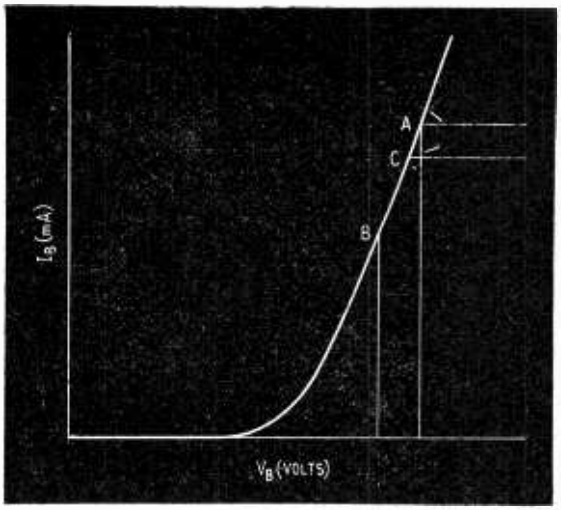

Fig. 5. Typical base potential/base current characteristic showing required operating point (A) and effect of zero—(B) and infinite—(C) impedance base circuits.

The upper limit to oscillator frequency is set by the transistor losses which occur mainly during transition between the conducting and non-conducting states, the collector potential rising to its peak value before the current falls to zero. The transition time is substantially constant irrespective of frequency, as it depends mainly on the transistor characteristics and the effective circuit capacitance. Therefore, the higher the frequency, the higher the losses.

At the oscillator frequency used in this equipment, i.e., 2 kc/s, the total transistor losses are approximately 5W and cooling fins of 24in^2 per transistor are sufficient.

The d.c.-to-a.c. converter feeds outputs to the heater transformer for the magnetron and local-oscillator klystron and to the h.t. transformer which is provided with tappings at levels up to 2kV. A voltage-doubler rectifier delivers 4kV for the magnetron modulator and further rectifiers multiply by six to give 11kV for the cathode-ray tube. High-voltage generation by multiplier was chosen because a suitable transformer cannot easily be wound with a self-capacitance of much less than 50pF. The transformer ratio is roughly 1 to 100 so that the effective capacitance presented by the transistors is about 0.5μF, which requires a charging current of two amps to change the p.d. across it by 40V in 10μ sec (the changeover time). Obviously a 4-kV winding would not be practical because the reflected capacitance would be four times bigger and would thus require a charging current of eight amps; which, together with the load current, is far in excess of the transistor's capabilities.

The lower-potential supplies have fairly low output impedances, as they are obtained directly from full-wave selenium rectifiers. Because of this, and the stabilization of the input to the converter, h.t. stabilizers are not necessary. The overall d.c.-to-d.c. efficiency of the converter and rectifier system is better than 85%, due partly to the absence of losses in smoothing chokes. This is most satisfactory, but even greater efficiencies can be obtained if fewer d.c. outputs are provided.

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Transistorized Wien Bridge Oscillator

INEXPENSIVE DESIGN COVERING 20-20,000 C/S

By F. BUTLER, O.B.E., B.Sc., M.I.E.E., M.Brit.I.R.E.

IT is not altogether a simple matter to design a wide-range variable-frequency oscillator using thermionic valves in the driving amplifier, and it is considerably more difficult to do so using transistors. In the case of the Wien bridge circuit there are three principal factors which complicate the task. The input impedance of a normal transistor amplifier is relatively low and it has a reactive component which can prove troublesome at high frequencies. The low impedance affects the performance of the frequency-determining components of the bridge, restricting the frequency range and making impossible demands on the maintaining amplifier. In the second place it is difficult to design a satisfactory circuit for amplitude control which will work effectively under the very-low power conditions which are normal in transistor circuits. Lastly, the characteristics of transistors vary widely from one sample to another of the same nominal type and these characteristics are strongly temperature dependent. With care it is possible to circumvent these troubles and to build a transistor oscillator comparable in performance with its valve-operated counterpart except in respect of output power and frequency stability. Wide range, low distortion and a good signal-to-noise ratio are readily obtainable. The small size, low power consumption and hum-free output of the battery-operated transistor oscillator are all points in its favour, and a long trouble-free life can be expected since all the electrical components are operated conservatively.

Valve-Operated Wien Bridge Circuits.—Before considering the design of a transistor oscillator it is instructive to examine some of the features of a conventional valve-operated RC bridge circuit. Fig. 1 illustrates a version recently described in *Wireless World*[1]. It is a fixed-frequency device designed to operate at 50 c/s. The frequency-determining elements R_1C_1 and R_2C_2 are of high resistance and reactance. They place almost negligible loading on the driving amplifier. The valve input impedances are virtually infinite so that the attenuation and phase shift of the interstage coupling networks can be held at an acceptable level, even at very low frequencies, by using conventional values of coupling capacitors and grid resistors. So much gain is available from the two-stage amplifier that it is possible to dispense with cathode circuit by-pass capacitors. The resulting negative feedback causes an increase in the already high input impedance of the valves.

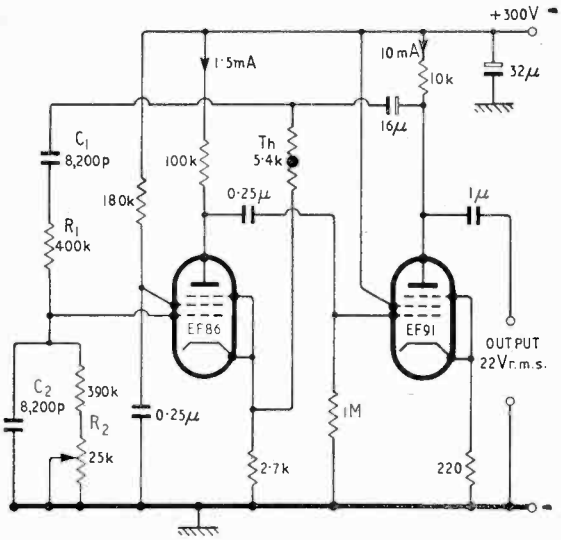

Fig. 1. Wien bridge oscillator using thermionic valves (design due to D. E. D. Hickman).

There is, in consequence of the high impedance of the bridge elements, some risk of high-frequency attenuation and phase shift due to the inevitable capacitance to ground of these and other components, particularly the interstage coupling capacitors. This is of little consequence in fixed-frequency oscillators but in wide-range circuits it may result in a requirement for separate scales on the various ranges. For example, in a three-range oscillator it will normally be found that on the lowest frequency range the phase shift due to the interstage coupling capacitor contributes considerably to the overall loop phase shift of the amplifier and feedback network. On the highest frequency range the interstage phase shift due to the coupling capacitor is negligible but on this range shunt capacitance becomes important. On the middle range, series and shunt capacitance in the amplifier circuit have only a small effect on the oscillator frequency which is determined almost completely by the Wien bridge elements. The effect of amplifier phase shift is to cramp the tuning range of the oscillator. Padding or trimming capacitance is thus required on some ranges if it is desired to use a single scale with decimal or decade multipliers to cover three ranges.

At this point it is worth drawing attention to another design feature of variable-frequency oscillators. In principle a change in either R or C in the bridge elements serves equally well to effect a change in frequency. If C is increased, the operating frequency will be lowered in such a way that the impedance of both arms of the bridge remains unchanged. The load on the driving amplifier stays constant and a change in frequency is not accompanied by a change in output level due to this cause. By contrast, if a frequency change is effected by varying R, then there is a change in the magnitude of the bridge impedance and a consequential change in oscillator output unless the

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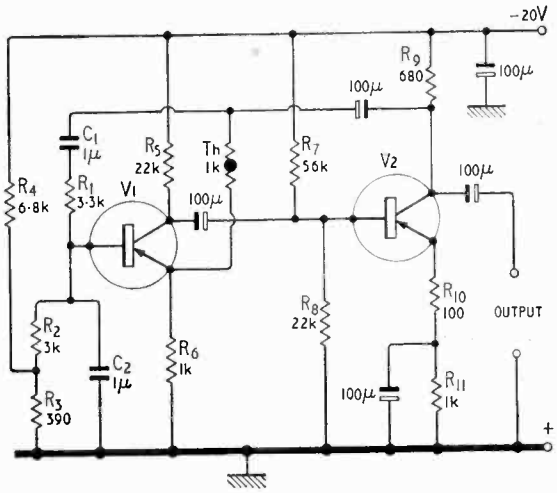

Fig. 2. Transistorized version of the Wein bridge oscillator of Fig. 1.

driving valve is of abnormally low output impedance.

The thermistor in Fig. 1 serves as an amplitude limiter. It has a large negative temperature coefficient which is exploited to control the oscillator output. Any increase in the output level causes a rise in the power dissipated in the thermistor element. Its temperature rises and the resistance falls proportionately. Since it is the series element in the negative-feedback circuit, the resulting degeneration restores the output very nearly to the original value. There are of course thermistor resistance changes due to room temperature variations but these are effectively swamped by the much larger changes due to internal energy dissipation changes caused by feedback from the output stage.

Consider now the direct transistor equivalent of Fig. 1 which is shown in Fig. 2. Typical component values are shown on both diagrams. In general, the lower impedances of the transistors call for corresponding reductions in resistance and for large increases in the value of coupling and by-pass capacitors. Minor changes in the input circuit of the first transistor V1 are called for to satisfy the base bias requirements. Corresponding changes are also required in the interstage coupling networks, but in other respects the circuits are virtually identical.

In spite of the superficial resemblances between Figs. 1 and 2, the transistor version would perform indifferently even if it worked at all. As shown, the input impedances of V1 and V2 might be of the order of 5,000Ω (using OC 71s, for example). That of V1 would impose a gross load on the parallel RC arm of the bridge, while that of V_2 would shunt the collector load of V_1 and reduce the stage gain. Even though coupling and by-pass capacitors of high values are used, they are associated with such low resistances that unacceptably large phase shifts would be experienced. Objectionable as these may be there are still worse defects to be overcome. Low-frequency operation calls for very large values of capacitance in the bridge network. Fixed capacitors must be used and frequency variation must be achieved by the use of ganged potentiometers. A practical difficulty is at once encountered, since any change of the resistances in the base circuit of V1 will alter its working bias. To avoid this trouble it might be possible to devise some complex resistance network which would serve to provide a fixed base bias current. It might be argued that some of the criticisms of the direct transistor analogue of the valve circuit are too sweeping and severe. For example, the low working voltages of transistor circuits make it quite practicable to use very high values of coupling capacitance, and to counteract the relatively high shunt capacitance it is sufficient to use very low collector load resistances. However, the amplifier gain then falls to an unacceptably low level and the current consumption rises to an uneconomic figure.

Fortunately it is possible to employ direct coupling between transistors with few of the penalties which are incurred when this technique is used with thermionic valves. This at once solves the problem of interstage phase shift and attenuation, though it calls for additional care in bias stabilization.

Finally, the use of negative feedback can transform the amplifier input and output impedances to almost any desired values. This practice can become extravagant in transistors if extremely high input or very low output impedances are required. The use of a single extra stage, properly employed, can raise the input impedance by a factor of 100 or more.

Transistor Amplifiers of High Input Impedance.—Fig. 3 shows three amplifier configurations which have a high input impedance. An emitter follower is shown in Fig. 3(a). It is roughly analogous to a cathode follower but the parallel is not exact. Internal feedback in the transistor circuit is respon-

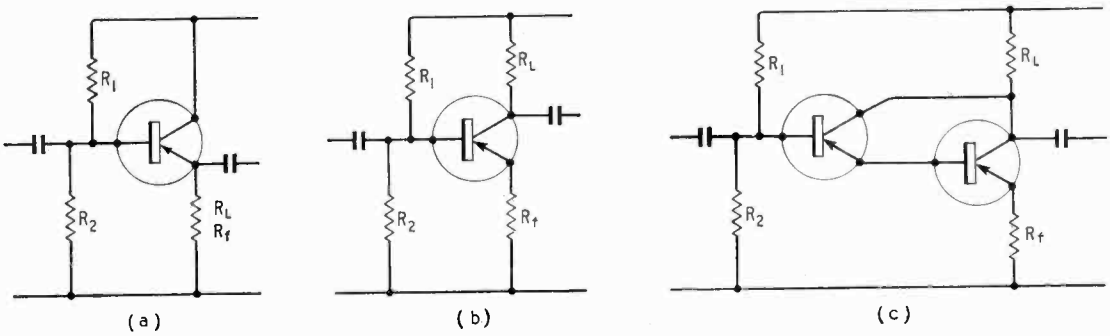

Fig. 3. Transistor amplifiers having a high input impedance: (a) is an emitter follower, (b) a feedback amplifier in which there is no decoupling capacitor in parallel with the emitter resistor, and (c) a "super-alpha" pair.

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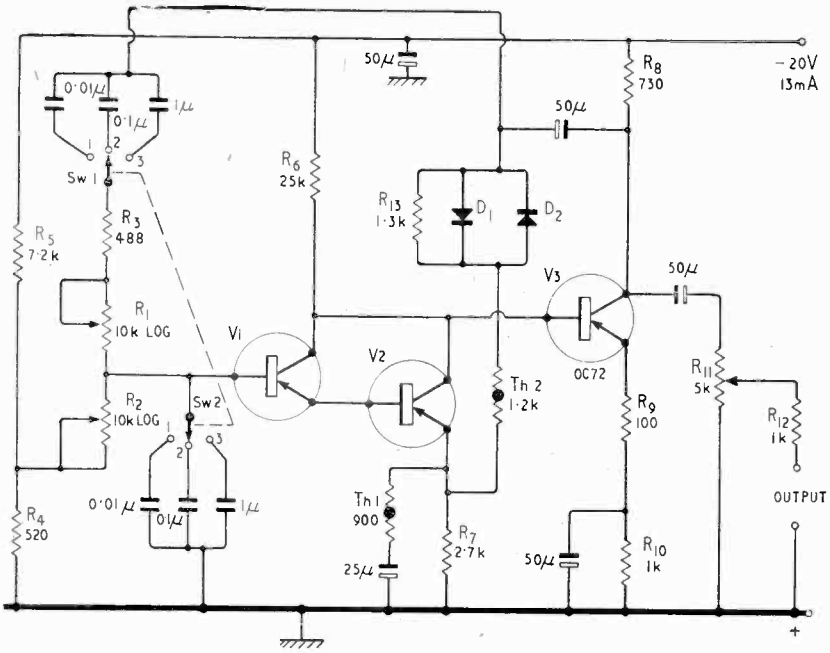

Fig. 4. Circuit diagram of a transistorized Wien bridge oscillator covering 20-20,000 c/s. (Half-watt resistors can be used throughout.)

sible for the differences. An emitter follower has a high input impedance only if it has a large load resistance. It has a low output impedance only if it is driven from a signal source of low impedance. Fig. 3(b) shows a feedback amplifier in which there is no decoupling capacitance in parallel with the emitter resistor. In this case the high input impedance is achieved at the expense of amplifier gain. To be really effective a two-stage amplifier is required with feedback over the two stages from the second collector to the first emitter. Using this technique it is easy to raise the first stage input impedance to a value of several megohms.

A rather less expensive solution is shown in Fig. 3(c). Two transistors are used to form a "super-alpha" pair. The base current of the second stage is the emitter current of the first. The first-stage base current is smaller than its emitter current by a factor which is of the same order as the current gain. Assuming that this is 100 and that the input impedance of the second transistor is 5,000Ω, the effective input impedance of the first stage becomes 0.5MΩ. The arrangement has other desirable properties. A large amount of negative feedback is provided which tends to linearize the characteristics of the transistor pair, and there is some improvement in the stability of the composite circuit in respect of temperature changes. Most textbooks on transistor circuits contain only a brief reference to the "super-alpha" connection although its special properties have been exploited, without explanation, in many recent circuits. Some of the foregoing remarks about its special characteristics thus warrant further comment. An emitter follower of the type shown in Fig. 3(a) has a voltage gain which is always less than unity. It can nevertheless provide a moderately high power gain which is due to current amplification within the transistor. An emitter follower can be used as a pre-amplifier to drive an earthed-emitter amplifier like that shown in Fig. 3 (b). Components may be saved and the composite amplifier may be used down to zero frequency by directly coupling the two stages. To do this it is sufficient to set the operating points of the two transistors at an optimum value by proper choice of the base bias resistances of the first transistor. This first transistor is then an emitter follower of which the load resistance is simply the input resistance of the second stage amplifier. The composite amplifier then has the high input impedance of an emitter follower. A single circuit change is now sufficient to arrive at the "super-alpha" connection shown in Fig. 3(c). It involves disconnecting the collector of the emitter follower from the negative h.t. line and joining it to the collector of the second transistor. The principal effect of this change is to place in series with the collector circuit of the first transistor the whole output voltage developed across the load resistance R_1. This voltage is opposite in phase to the amplifier input voltage and constitutes a large series negative-feedback signal. The effect of this is to cause a further increase in the already high input resistance of the first transistor and to linearize the characteristics of the transistor pair.

Wide-range Oscillator Circuit.—Fig. 4 shows the complete circuit diagram of a Wien bridge oscillator covering 20 c/s to 20 kc/s in three overlapping ranges. A point-to-point wiring diagram is given in Fig. 5. Coarse frequency changes are made by a 2-gang 3-pole switch, used to select matched pairs of capacitors. Fine tuning is effected by a 2-gang potentiometer, R_1 R_2, having a semi-logarithmic winding law. A linear winding is acceptable for most purposes and such a component may be more readily available than that actually used in the prototype oscillator.

Because of the very high input impedance of the first transistor its bias current is quite small and is not seriously affected by variations of the main tuning resistances R_1 and R_2. Direct coupling between the three transistors saves components and avoids the phase shifts which would be caused by coupling capacitors and base-bias resistors. Variations of bridge impedance over each tuning range are due to changes in the resistive arms of the bridge. These effects are minimized by the use of an amplifier V3 of very low output impedance. A Mullard OC 72 is used in this stage. Transistors V1 and V2 should have characteristics similar to the OC 71.

Two thermistors are used for amplitude limitation. The main control is exercised by Th 2, which is the negative-feedback element. It is a glass-

(*Continued on page* 389)

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sealed Type A thermistor, manufactured by Standard Telephones and Cables. The sample used had a resistance of 1200Ω, measured at room temperature and near-zero current. This element is not ideally suitable for transistor applications. Preferred types, specially manufactured for low power control and regulation, are the S.T.C. thermistor Types R.53 or R.14. The difficulty with physically large thermistors is that the resistance changes due to ambient temperature variations may exceed those due to changing oscillator signal levels.

The use of a second Type A thermistor, Th 1, (whose resistance should not be significantly greater than that of Th 2) serves to give partial compensation for room-temperature changes. In series with a large capacitor, it is connected in shunt with the emitter resistor of V2. Here the signal level is so low that it has a negligible effect on the thermistor resistance. By contrast, the resistance of Th 1 is markedly dependent on the room temperature. A rise in temperature causes a fall in resistance and a consequent reduction in the negative-feedback voltage applied to V2. This, in part, neutralizes the effect of a decrease in the resistance of Th 2 caused by the same room-temperature changes. The signal level in Th 2 is high enough to cause additional resistance changes, sufficient in practice to give a reasonable degree of control of the output amplitude.

In series with Th 2 is another control element. This consists of a pair of germanium junction diodes (such as B.T.-H. Type GJ3-M) connected in parallel but with opposed polarity. These constitute a non-linear resistance, the magnitude of which depends on the instantaneous voltage drop across the diodes. With an infinitesimal p.d. across the diodes their effective resistance is almost infinite. It drops to a few ohms with an applied e.m.f. of about 250 mV. A resistance shunt R_{13} across the diodes limits their maximum effective resistance at low signal levels. The use of this non-linear circuit element ensures reliable oscillation over a wide range of temperatures. This it does at the expense of some waveform distortion. The degradation is barely perceptible on an oscillogram, but is undesirable when the oscillator is being used to make distortion measurements on high-grade amplifiers. If the oscillator is to be used only at normal room temperatures and is not exposed to extreme variations the diodes may be omitted, or a short-circuiting switch may be fitted if it is desired to retain them for use under abnormal conditions. If a thermistor Type R.53 is substituted for Th 2 the diodes are certainly unnecessary, but a Type A unit should still be used in the emitter circuit of V2.

It might be thought that amplitude control by thermistors must necessarily result in some non-linear distortion. This is not the case, since the thermal capacity of the resistance element is so large that, except at the very lowest frequencies, the resistance does not change significantly during the time of one cycle of the oscillator frequency.

The actual distortion produced by the diodes is dependent on the signal level and on the value of the shunting resistance R_{13}. It is very slightly affected by the thermistor resistance in series with the shunted diodes. Diode distortion is a function of signal amplitude and is virtually independent of frequency.

As regards components, those shown in Fig. 4 are a mixture of preferred and non-preferred values, arrived at by actual measurement. There are only two really critical components, R_3 and R_4. These set the high-frequency limits on each tuning range and their ratio affects the bridge attenuation which, in turn, calls for corresponding adjustments of amplifier gain. The base-bias resistance R_5 is also fairly critical. The best procedure is to complete all the circuit wiring with the exception of R_3, R_4 and R_5. External variable resistances should then be connected temporarily in circuit and the correct settings established by trial. The aim should be to produce the best possible waveform on each range and to equalize the output level at the extreme ends of each range. The maximum undistorted output is 1V r.m.s. into 1,000Ω.

As regards frequency calibration, the best procedure on the low-frequency range is to establish the main points on the scale by reference to a 50 c/s signal. A precise comparison of frequencies which are integral or simple fractional multiples of each other can be made by observation of Lissajous figures on an oscilloscope.

The high-frequency ranges call for the use of

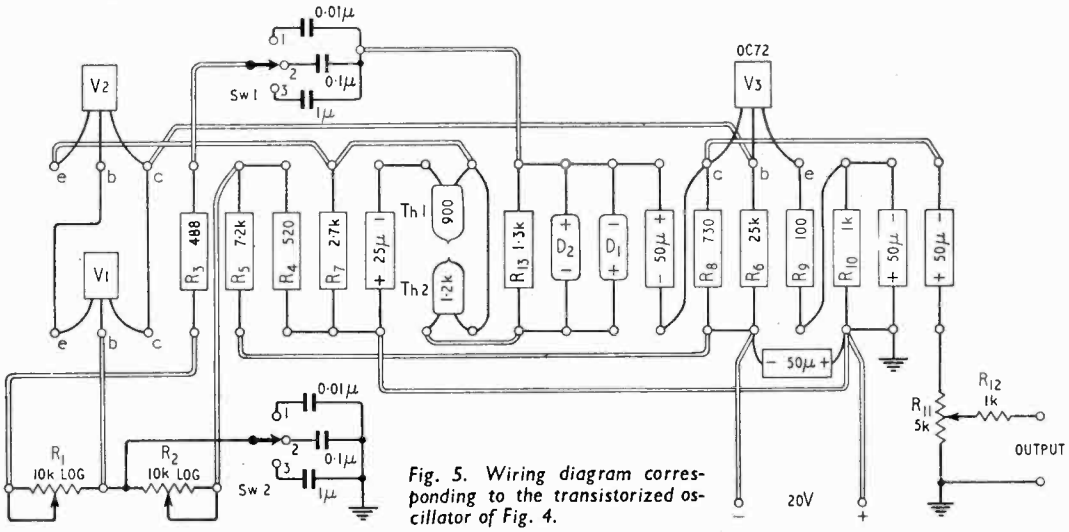

Fig. 5. Wiring diagram corresponding to the transistorized oscillator of Fig. 4.

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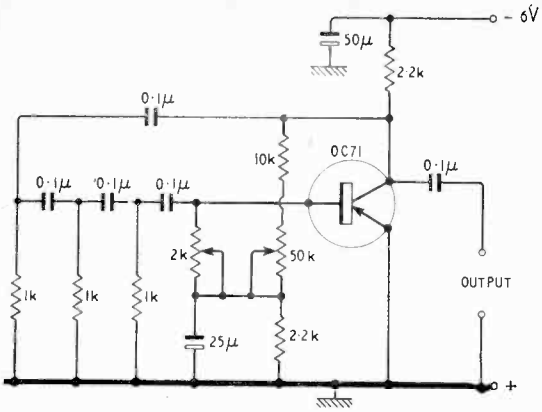

Fig. 6. 1,000 c/s auxiliary oscillator for calibration purposes. (Half-watt resistors can be used throughout.)

auxiliary oscillators. Fig. 6 gives a simple circuit of a 1 kc/s oscillator which can be calibrated against a 50 c/s signal and set precisely on frequency by the adjustment of the 2kΩ potentiometer, again using a Lissajous display. The 50kΩ variable resistor has a small effect on the generated frequency but its main function is to set the transistor base bias for maximum undistorted output. This oscillator can be used to check most of the mid-frequency and high-frequency ranges. On the 20 kc/s range, the higher-frequency points can be checked against a 100 kc/s crystal-controlled oscillator.

To avoid the considerable labour of matching all the ranges to permit the use of a single scale with decade multipliers, it is much simpler and less cumbersome to use separate scales for each range. Alternatively an arbitrary scale of 100 or 180 divisions may be used in conjunction with conversion tables or charts.

Range Extension.—Experiments show that with high-frequency transistors there is little difficulty in adding a further range covering up to 200 kc/s and in fact a slightly modified circuit using American 2N 499 v.h.f. transistors operated reliably up to 2.3 Mc/s. At such high frequencies, variable capacitors become more useful than variable resistors as the tuning element. There is little point in using RC oscillators at frequencies much higher than 100 kc/s since it is simpler and cheaper to use switched tuned circuits.

Crystal-Controlled Oscillator.—The amplifier circuit shown in Fig. 4 is easily convertible to a precision low-frequency crystal oscillator. The crystal is merely substituted for the series RC arm of the Wien bridge network. The other arm is reduced to a pure resistance by removal of the shunt capacitance. At its series resonant frequency the crystal behaves as a pure resistance. Off-resonance it simulates a very high reactance. The crystal acts as one segment of a voltage divider, the other being the resistance between the base of V1 and earth. Off resonance the amplifier input voltage is attenuated and its phase is changed so that oscillation is made impossible. At series resonance the low effective resistance of the crystal results in the development of sufficient amplifier drive to start and sustain oscillation. The amplitude control circuit functions as in the Wien bridge arrangement to ensure strict Class-A operation. Because of the strong negative feedback, variations in transistor parameters due to temperature and supply voltage changes have only a minor effect on the frequency stability. Considerable development work would be required to bring up the performance of such an oscillator to meet the exacting specifications of modern frequency standards. It would be necessary to employ v.h.f. transistors in order to reduce the amplifier phase shift to a satisfactory level. Temperature control of both crystal and amplifier would be required and the supply voltage would need to be stabilized. Preliminary tests show that the performance of the simple circuit is good enough for many purposes. Its outstanding feature is that the operating conditions can be adjusted to set a definite limit to the amplitude of vibration of the crystal. The harmonic content of the oscillator output is then extremely low.

Variable Inductors.—It seems probable that suitably designed variable inductors could be used in conjunction with fixed resistors as the frequency determining elements of an audio oscillator instead of the variable resistors and capacitors normally used.

One possible scheme would be to use twin solenoids with moveable ferrite cores. Range-changing requirements could be met by the use of suitably tapped coils. Such a system would present a constant impedance to the driving amplifier and this would ease the problem of securing constant output over a wide range of frequencies.

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Microwave Instruments, including attenuators, loads, oscillators, transformers, wavemeters, power supplies and many other special components. An extensive illustrated catalogue covering the complete range of products from Decca Radar, Ltd., Decca House, 9 Albert Embankment, London, S.E.11.

Bench Assembly Trays and storage bins in polythene and other plastics. Various sizes and shapes, some designed for stacking and others for interlocking side by side. Leaflets from "Kabi," Precision Components (Barnet), Ltd., 13 Byng Road, Barnet, Herts.

Television Aerials, masts and accessories. The complete range of Band-I, Band-III and combined types, including v.h.f. aerials, is displayed on a broadsheet from Telecraft, Ltd., Quadrant Works, Wortley Road, Croydon, Surrey.

Ultrasonic Cleaning Equipment for use on small parts and assemblies. Operating at 40kc/s, the generator delivers 250 watts peak either into a complete tank and transducer assembly or into an immersible transducer. Technical details on a leaflet from Dawe Instruments, Ltd., 99-101 Uxbridge Road, Ealing, London, W.5.

Industrial TV Equipment, with a photoconductive camera in a cast aluminium weatherproof housing for use under extreme weather conditions. Pan (up to 350°) and tilt (up to ±90°) equipment is remotely operated from a control unit. Operation on 625-line standards. Leaflet from Te-Ka-De, Nuremberg, W. Germany.

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Microwave Valves

INTERNATIONAL CONGRESS AT MUNICH

A SOMEWHAT unusual general feature of the recent Munich Congress was the relatively large number of survey papers given. These should lend an added interest to the forthcoming publication of all the congress papers (in their original languages) as volume 22 of *Nachrichtentechnische Fachberichte*. Since as many as 145 papers were given, three simultaneous sessions had to be run. Fortunately, by choosing what he hopes were the most novel and important papers, your reporter generally managed to avoid having to be in several places at once. For reasons of space, this report must be even more selective.

Magnetrons

One of the problems of magnetron design is ensuring complete stability in the desired mode of oscillation. This is because the r.f. waves associated with the many unwanted modes (and indeed also with the wanted one) have velocities which remain constant round the anode structure. Electrons with a constant and suitable velocity can thus interact favourably with all modes. A general way of avoiding such unwanted interaction which was described in a paper by D. A. Wilbur *et al* is to make the velocities of the unwanted modes vary round the anode so that these modes cannot interact with electrons of constant velocity. (At the same time the velocity of the desired mode must of course be kept constant round the anode.) These conditions can be satisfied by making the anode up out of two or more sets of resonators whose frequency/phase shift characteristics are the same only for the desired mode. Two examples of anode structures which can be made to satisfy this criterion are a combination of forward- and backward-wave sections or alternatively, a number of different-sized cavities arranged in a random sequence. Tapering the cavity dimensions towards the end of a travelling-wave tube to suppress backward-wave oscillations in a somewhat similar way was discussed in a paper by M. Chodorow *et al.*

A paper by W. E. Willshaw mentioned a way of facilitating third harmonic operation of magnetrons. This is done by making the anode up out of two sets of cavities—one set resonating at the fundamental frequency and the other at the harmonic. Twice as many harmonic as fundamental cavities are provided, so that electron bunches produced at the fundamental frequency have the correct angular velocity for interacting with the harmonic.

Klystrons

A paper by J. Favalier described an unusual method of electrically varying the frequency of a klystron. This method uses an external tuning cavity in which a gas discharge is set up. To microwaves such a discharge looks rather like a dielectric whose permitivity depends on the electron density and thus also on the discharge current. By varying the discharge current one can thus also vary the tuning-cavity resonant frequency and consequently also the klystron frequency. The frequency of an X-band (~ 9,000Mc/s) klystron could thus be varied by more than 500Mc/s by increasing the discharge current from zero to 250mA.

Travelling-Wave Valves

A paper by O. Doehler and G. Mourier discussed the theory of valves in which an electron beam interacts with a slow-wave structure which is periodic in two dimensions. Such a structure is a more general version of a number of ordinary structures in parallel (in which case the distance between adjacent structures is the second periodicity) so that it should be capable of dissipating high powers. The gain was calculated for the case of the transversotron in which the r.f. energy is propagated in a direction at right angles to that of the beam. This device is reciprocal, i.e., can amplify forward- or backward-going signals equally well. Thus in order to prevent feedback and consequent oscillations, a non-reciprocal device such as an isolator must be included.

Backward-Wave Valves

A paper by W. Wendrich described a way of using such valves as mixer oscillators. (For a description of the backward-wave valve see, for example, the article by C. H. Dix in *Wireless World* for November 1959 (p. 478)). In this modification, the output (at the electron gun end of the slow-wave structure) is terminated in a matched load, and the input is fed to the other end of the slow-wave structure. Both the input and oscillator thus modulate the electron beam and, since the modulation is non-linear, combinations of the oscillator and input frequencies are also produced at the same time. The microwave sum frequency is absorbed in the output load, and the low difference frequency may be picked up at the input.

A paper by A. W. Trivelpiece showed that a longitudinally magnetized ferrite rod can propagate backward waves with velocities of the order of one hundredth of that of light. Interaction with such waves and a beam passing through an axial hole in the ferrite was observed. Such a simple slow-wave structure should be very easy to make.

Crossed-field (M-Type) Valves

Some of the work on the best-known example of this type of valve—the magnetron—has already been described in this report.

A paper by E. Dench *et al* discussed the bitermitron. This is similar to a crossed-field backward-wave oscillator (for a fuller description of which see, for example, the previously mentioned article by C. H. Dix in our November 1959 issue (p. 480)) except that, instead of one end of the slow-wave structure being internally terminated in a matched load, both ends are taken out to external circuits. This difference accounts for the first part of the

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name, the iron being added, as the authors put it, because this is essential for satisfactory operation. The bitermitron can be operated as a conventional voltage-tuned backward-wave amplifier or oscillator. More interesting is the possibility of operating it as a locked oscillator at high-power levels. An advantage of this arangement is that in the event of failure of the driver oscillator, the bitermitron will continue to oscillate.

A paper by J. E. Orr described a way of controlling the beam current by means of a closely packed parallel-wire grid in front of the cathode emission surface. Normally, any electrodes near the cathode are used for shaping the beam, and the current is controlled by varying the voltage of an accelerator electrode near the entrance to the slow-wave structure. However, the use of a grid control enabled a seven times greater charge in the beam current to be obtained for a given control-voltage change. Little change in the r.f. characteristics was produced by the addition of the grid. An interesting method was used to observe the effect of different electrode positions. A model scaled-up in size (and electrode voltages) was placed in a large evacuated chamber. This was big enough for a man in a space suit to go in and adjust the electrodes to give a suitable beam shape, the beam position being photographed from the light produced through excitation by the beam of the residual gas in the chamber.

Tornadotron

A paper by G. E. Weibel and R. H. Bartram described the theory of a device for converting microwaves to sub-millimetre waves at high powers. Electrons are first injected and trapped inside a chamber in a magnetic field. By making the frequency of a microwave input resonate with that due to cycloidal motion in the magnetic field (cyclotron resonance) orbital motion of the electron cloud is next induced. It is then proposed to multiply the orbital frequency and its associated rotational energy by a factor of between 100 and 1000 by means of a very large ($\gtrsim$ 100,000 gauss) pulsed magnetic field. Power at sub-millimetre wavelengths should then be radiated directly from the rapidly swirling electron cloud. This cloud actually swirls on its own axis as well as round its orbit—hence the name of the device.

Noise Reduction

In spite of, or perhaps because of, the recent discovery of new types of valve—such as the parametric amplifier—with very low noise characteristics, many new ideas for reducing noise in conventional valves are being investigated. Moreover, earlier pessimistic theoretical calculations of the minimum possible noise figure in such valves (which was not much less than what had already been achieved in practice) are no longer regarded as valid. A survey paper by M. R. Currie included a discussion of noise reduction in conventional valves. In such valves it can be shown that nearly all the noise is produced at the beginning of the device, near the cathode and potential minimum. It is on modifying the electron velocities in the multi-velocity region just beyond the potential minimum that many of the newly proposed methods of noise reduction depend. These electron velocities can be modified by depressing the potential minimum by the space-charge effect of high-density injected electron beams or, more usually, by modifying the beam profile either by means of special electrodes near the cathode or by shaping the cathode emissive surface itself. The noise can also be reduced by confining the emission to the edge of the cathode. In general, the use of two- rather than single-dimensional concepts is an advantage in this field. Space-charge effects can also reduce the noise, and since the extent of such reduction varies with the frequency, it may be advantageous to operate at certain frequencies to obtain low noise.

Modulation in an electron beam is usually propagated along it in two waves. One—the fast wave—has a velocity greater than that of the beam itself and the other—the slow wave—a velocity less than (but usually similar to) the beam velocity. Until recently microwave valves have relied on interaction between the slow electron beam wave and a circuit, and it has usually been thought that it is impossible to completely remove the noise from this slow electron beam wave. A paper by P. A. Sturrock, however, not only suggested flaws in the reasoning by which this impossibility is deduced, but also proposed a possible general method of removing the noise from a slow wave. In this method the fast and slow waves are parametrically coupled together by a pump signal in such a way that any noise on the two waves is interchanged periodically along their lengths. The noise can thus be removed from the slow wave if the noise on the fast wave has previously been removed. This can be done by a somewhat similar interchange process which is already known and which will be briefly described later in this report in connection with transverse-field valves.

A method of noise reduction which should be applicable to both slow and fast electron beam waves was described in a paper by R. Adler and G. Wade. This depends on the fact that for an electron beam spiralling in a longitudinal magnetic field, the noise temperature for transverse modulation (at right-angles to the direction of the beam motion and magnetic field) can be shown to be proportional to the ratio of the signal to the spiralling (cyclotron) frequencies. By using a large magnetic field to give a high cyclotron frequency, the noise can thus be reduced. Moreover, the field need not be kept large throughout the valve since it can be gradually reduced beyond the initial noise-reduction region without increasing the noise. Experimental results showed a reduction in the fast wave transverse noise temperature from 1100°K to 180°K for a cyclotron frequency nine times that of the signal. The main problems in applying this method arise in designing a transverse-field input coupler which will operate at a fraction of the cyclotron frequency (rather than, as is usual, at the cyclotron frequency) and, of course, in providing a magnetic field high enough to give a cyclotron frequency several times that of the signal.

Periodic Electron Beams

Until recently microwave valves have relied for their operation on synchronism between r.f. waves and the longitudinal velocity of an electron beam. Thus, since the velocity which can be attained by electrons is necessarily limited, special slow-wave structures which are capable of propagating r.f. waves with velocities as slow as those of the electrons have to be provided. As the wavelength is decreased, such structures become correspondingly smaller. They

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are then more difficult to make and cannot dissipate so much power. In addition, the r.f. fields also fall off more rapidly away from them and so interaction with electron beams is more difficult to achieve. Slow-wave structures are generally either periodic, like the helix, or resonant, like the cavities in a magnetron. Aperiodic, non-resonant, smooth-wall circuits (such as waveguides), which would be easy to construct, can normally only propagate fast r.f. waves, i.e., waves with phase velocities equal to or greater than that of light and thus greater than that of any possible electron beam. Electrons can, however, interact with a fast wave by travelling not in a straight line but rather in a periodic path which is made to correspond to the spatial or time periodicity of the r.f. wave in such a way that any given electron always sees the same value of the r.f. field.

A paper by C. K. Birdsall and L. Haas discussed beams which are made to follow a zigzag path along a waveguide by means of repelling electrodes outside the guide. Up to 21 crossings have been successfully induced, about 40% of the beam being transmitted through six crossings. In fact, however, only a small number of crossings is necessary for interaction, for similar reasons as in the case of a reflex klystron where the beam passes only twice through the cavity. The beam can interact with either forward or backward waves, possible output frequencies being those at which the r.f. wave slips a whole number of wavelengths per zigzag ahead of or behind the beam.

Birdsall and Haas also discussed beams which are made to follow a helical path between two concentric cylinders by balancing the outward centrifugal force against an equal inward force produced by an electrostatic field applied between the two cylinders. Here for interaction, the frequency of helical rotation must be equal to the required output frequency, neglecting any motion of the electrons in a direction along the cylinders' axis.

Papers by A. Reddish and by A. H. Beck and R. F. Mayo described beams which are made to follow a cycloidal path by means of a magnetic field. (It is interesting to remember that such motion was in some cases responsible for the operation of early magnetrons.) In such motion the cycloidal radius depends on the electron velocity. Thus the unfavourable electrons which gain energy from the r.f. field are automatically separated from the favourable electrons which lose energy to the r.f. field. For interaction, the cycloidal frequency must equal the required output frequency, neglecting any electron motion along the field.

A disadvantage of this system is that to produce short wavelengths high magnetic fields are required (field $\approx$ 10,000 gauss divided by wavelength in centimetres). This could be avoided if the cycloidal motion could be at a sub-harmonic of the required output frequency. The paper by Beck and Mayo showed that in this case interaction is still possible, provided that the r.f. field has an azimuthal spatial periodicity corresponding to the sub-harmonic used. Thus, for example, the TE_{m1} waveguide mode can interact to produce output at m times the cycloidal frequency.

Transverse-field Valves

These are valves in which the r.f. field, and consequently also the electron modulation motion, are at right angles to the electron beam motion. Since a transverse-field parametric amplifier with very low noise was developed by R. Adler (see the *Technical Notebook* section of our November 1958 issue (p. 555) or for a full account *Proc.I.R.E.* for June 1958 (p. 1,300) and October 1958 (p. 1,756)) much interest has been shown in such valves, and a number of devices more or less similar to the Adler tube were described at the conference. Two of these were simply microwave versions of the Adler tube (which has a relatively low operating frequency around 600 Mc/s)—one due to A. Ashkin for 4,140 Mc/s and the other due to T. J. Bridges for 2,700 Mc/s.

The orginal Adler tube used input and output couplers of the Cuccia type, which were first described in *R.C.A. Review* as "long" ago as June 1949 (p. 270). In such couplers the r.f. input signal is applied via suitable circuits across two deflection plates on opposite sides of the beam. This produces transverse r.f. fields across the beam. A longitudinal magnetic field is also applied to produce spiral motion of the beam along the field. When the input frequency across the coupler is made equal to the cyclotron spiralling frequency, the phenomenon of cyclotron resonance produces an increase in the spiral radius. In this device the coupling is between the fast electron-beam and r.f. waves. It has the great advantage that under certain conditions (such as, for example, for a particular length of coupler) the beam noise is, in theory, totally removed to the coupler (and in practice nearly so) as the r.f. input signal is transferred to the beam.

One disadvantage of the Cuccia coupler is the fact that the coupler signal input frequency is tied to the magnetic cyclotron frequency. A paper by P. A. H. Hart discussed theoretically a method of obtaining a somewhat wider choice of possible signal frequencies relative to the cyclotron frequency. In this method, slow-wave deflection circuits are used to produce transverse r.f. signal fields which travel along the electron beam. The phase velocity along the beam of the r.f. signal is chosen relative to the longitudinal beam velocity so that an observer travelling with this beam velocity would see, because of the Doppler effect, a transverse field not at the signal frequency but at the (in this case lower) cyclotron frequency. Resonance between the apparent signal frequency and the cyclotron frequency, fast-wave coupling and noise removal are then possible as in the Cuccia coupler. A greater bandwidth should, however, be obtainable than with a Cuccia coupler. (Doppler shift concepts similar to that just described were of importance in several of the interaction processes discussed at the conference.)

A paper by W. R. Beam described experimental results on the use of a slow-wave helix to couple to a hollow beam. Here again the input frequency was not tied to the cyclotron frequency. Unfortunately the results obtained did not agree with those to be expected on conventional coupling theories and have not yet been explained.

A paper by R. H. Pantell discussed the theory of a transverse-field coupler which uses a d.c. electrostatic rather than a magnetic field. In this coupler, as in the periodic beam device described by Birdsall and Haas which we have already mentioned, spiral motion of electrons is produced between two concentric cylinders by balancing the outward centrifugal force against that produced by an electrostatic

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field applied between the two cylinders. For interaction the spiralling frequency must equal the signal frequency as in the Cuccia coupler, and again fast-wave coupling and noise removal are possible for a certain critical length of coupler.

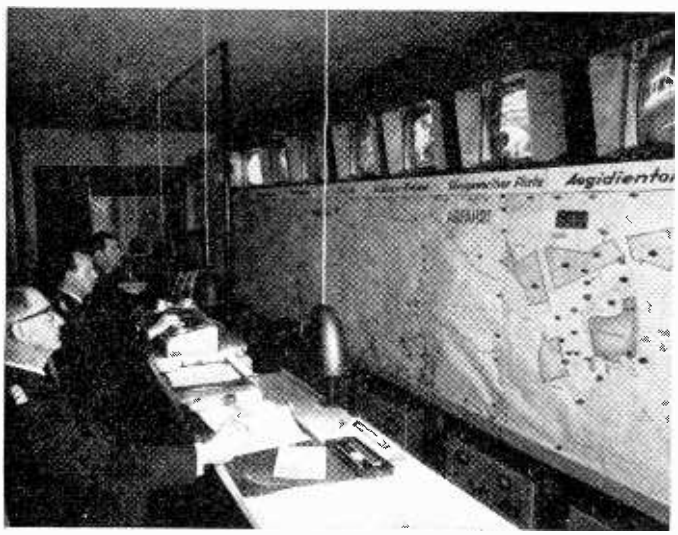
Couplers such as we have just been describing can only put spiral modulation motion on to the beam and are not capable of amplifying this motion. One or more quadrupoles were used to produce amplification in almost all the transverse-field valves described at the congress—indeed one author said he would not have dared to describe his device if it had not used a quadrupole. Such quadrupoles each consist simply of four deflection plates spaced round the electron beam. Adjacent plates are given opposite electric potentials so as to produce fields which are tangential to the spiral motion of the beam. Amplification of the spiral modulation motion is produced by arranging for any given electron to continually see an accelerating tangential field as it spirals along the tube. This can be done by means of either a time- or space-varying quadrupole field, i.e. either by applying a pump r.f. field to a single quadrupole or alternatively, by applying direct voltages to a number of quadrupoles which are rotated and suitably spaced relative to each other. The latter system was used in several of the new devices described at the congress: the former was used in the original Adler tube.

When an r.f. pump field is used, this provides the energy necessary to produce amplification. In the original Adler tube, to correspond to the two pairs of plates in the quadrupole, the pumping had to be at twice the spiral (signal) frequency. A paper by J. E. Carroll discussed the possibility of pumping at a rather lower frequency—two-thirds of that of the signal. In this case the pumping process can be considered as an initial interaction between the pump and signal to produce a difference signal (at one-third of the original frequency), followed by pumping of this difference signal as in the Adler tube at twice its own frequency (i.e., at two-thirds of the original frequency). With this method of pumping the noise should be as low as in the Adler tube. Other effects may, however, prevent its successful practical realization. Pumping at the signal frequency was discussed in a paper by E. J. Gordon and A. Ashkin.

Amplification by means of a number of spaced relatively-rotated d.c. quadrupoles may be loosely described as being with a zero pump frequency. The energy required to produce amplification is, however, no longer obtained from the pump field, but rather from the d.c. beam energy, longitudinal beam kinetic energy being converted into spiral rotational energy by the d.c. quadrupoles. In the example described by J. C. Bass, adjacent quadrupoles are spaced one quarter of a cyclotron wavelength apart and rotated through ninety degrees relative to each other. Identical results are obtained by not rotating the quadrupoles but instead reversing the signs of the applied direct potentials between adjacent quadrupoles. Apparently d.c. quadrupoles will not give low noise, but should on the other hand be capable of producing higher power outputs. The absence of an r.f. amplifying structure would, of course, be an advantage in constructing very high-frequency devices.

Possibilities of getting away from the quadrupole as an amplifier by using a helix and hollow beam were described in the paper by W. R. Beam already mentioned. In this case also pumping need not be at twice the signal frequency. The possibility of using a number of spaced magnets as a spiral motion amplifier was mentioned in a paper by K. Blotekjaer and T. Wessel-Berg.

TRAFFIC CONTROL AT HANOVER



RADIO communications play an important part in the special police arrangements for traffic control in Hanover, particularly during the period of the annual Trade Fair, when upwards of 40,000 cars may be added to the normal traffic streams during the morning and evening rush hours.

Television cameras mounted at strategic points are connected by links in the 6,700 Mc/s band with display units at a control centre on the top of the 170 ft high Electrotechnical Hall of the exhibition. These displays give an overall picture of the traffic situation in Hanover and its environs.

This year remotely controlled steerable cameras (supplied by Te-Ka-De and Felten and Guilleaume of Nürnberg) were used for the first time at multiple road junctions and an additional circuit was made available for a camera fitted in a patrolling helicopter.

The traffic-control officer (second from left) is operating the "joy stick" of one of the remotely controlled television cameras.

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LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

Circuit Conventions

AS the subtitle to Patrick Halliday's article, "Better Circuit Diagrams," was in the form of a question, presumably comments were invited.

The use of the nanofarad is a practice I applaud—see the preface to "Radio Laboratory Handbook," 6th edition. The same goes for omitting Ω, F and H, with the object of making it easier to specify values on the circuit diagram instead of in a list.

Saving time in the drawing office is certainly a valid motive for re-examining our graphical symbols. But any competitive candidates must themselves be able to stand examination. The following are some comments on Mr. Halliday's recommendations.

The rectangle for a resistor is much less easy to sketch than the traditional zig-zag, nor need the latter take up much time in more formal drawings if the number of strokes is kept small. If the rectangle can be drawn with a stencil, so too can the zig-zag. There are other things than resistors for which rectangles are more suitable—general impedances, for example. The wattage code shown makes no provision for resistors of unspecified wattage; unless otherwise specified they are all ¼W! The same objection applies to the capacitor voltage code.

For sketches, the present inductor symbol is unrivalled, but for formal drawings there is certainly an advantage in the row of semicircles, and in the "block" method of drawing mains transformers.

The proposal to substitute a single stroke for both earth and chassis connection symbols is most ill-advised, however, as the vital distinction between these two is thereby obliterated.

There is no need whatever to cause confusion by using a black spot (which already signifies "electrode with special function") in place of the BS.530 cathode symbol—admittedly a time waster if drawn accurately to standard. A simple curved or bent line is sufficient. And as for the segmented spot to indicate a cathode common to other parts of a multiple valve, it seems to have nothing in its favour. It fails to show which other electrodes it is related to, and is not even easy to draw. Again, what is wrong with a simple line?

To sum up: some, at least, of the foreign practices deserve consideration *for working diagrams of equipment.* Presumably they were put forward with this qualification understood. They are less suitable for diagrams illustrating principles or techniques, and still less for engineers' sketches.

Bromley, Kent. M. G. SCROGGIE

AS a technical author, I agree strongly with Patrick Halliday about circuit element symbols. In the production of literature on electronic subects, circuit diagrams are major items. Currently conventional symbols demand space which is very scarce in a big, complicated diagram; they convey only one order of information—"values" take up added space; they are tiresome to draw neatly and their sizes create difficult problems in overall lay-out. These archaic shortcomings give rise to consumption of time and money, in the preparation of diagrams, which could be greatly reduced by universal adoption of an intelligent new code of symbols.

The most significant word, however, in the last sentence above is "universal." Confusion arising from regional codes and styles is already present and will increase if anarchy in symbolic representation is allowed to continue. We may eventually need "dictionaries" to understand "local dialects" in electronic pictorial language. There is, therefore, I suggest, a real and urgent requirement for the setting up of some authoritative body to devise a new code which, by virtue of its advantages, would soon replace all regional variants from Tokyo to London.

London, E.17. W. H. CAZALY

IN your editorial of June, 1960, you speak of "following BS 530 slavishly." This is not possible in every case since BS 530, like so many British Standards, frequently offers a choice with a preference instead of laying down a unique standard. The convention of crossing wires is a case in point.

Then when symbols are required for heavy electrical applications not included in BS 530, one looks in BS 108. Here one finds some useful additional symbols but a whole lot more which are in direct conflict with BS 530. An example is relay or contactor contacts, where BS 108 distinguishes between relays and contactors, main and auxiliary contacts, and different physical assemblies of contact (single and double break), and at no point agrees with BS 530.

The British Standards Institution's intention to coalesce these two standards is urgently needed, but it is no small task.

London, N.W.10. R. S. FERGUSON
Leo Computers Ltd.

REFERRING to Mr. L. H. Bedford's letter (April 1960) concerning circuits diagrams, I wish to express to your goodselves that I was very glad that you did not fall in with his ideas, maintaining the usual procedure in drawing diagrams.

With looped crossings and staggered junctions, one minimizes the chances of mistakes. As regards the valve's envelope, I believe that same ought also to be drawn: one cannot think of a vacuum tube without its envelope, therefore said envelope plays its role and should appear on the diagrams.

A. EDUARDO DINIZ SCHLAEPFER,
Eng. Diretoria de Rotas Aéreas,
Ministério da Aeronáutica.

Rio de Janeiro, Brazil.

I REMEMBER the time when the symbols representing the various components in a circuit diagram (I refuse to use that horrible Americanism—"schematics") were simplified sketches of the actual thing. For example, a standard dry cell, then the most commonly used source of electrical energy, was represented as in (a). The thick black rectangle is the carbon plate and is, of course,

(a) (b)

positive; while the thin circle indicates the zinc can and is negative. Later, as a time and space saving expedient, the zinc can was flattened and the terminal omitted as in (b).

Modern draughtsmen insist on reversing the polarity of the symbol so that the thick black stroke is negative and the thin stroke positive. When this is queried, it is pointed out that the present back-to-front polarity is laid down in a Government publication. I should be

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interested to hear if there is a valid reason for this change.

London, W.13. J. C. BAKER

V.H.M./F.M. Car Radio

Mr. Blanchard (July issue) was disappointed with the results given by his v.h.f./f.m. car radio, both here and on the Continent; however, his remarks indicate likely causes of this unsatisfactory performance.

I stated that an omnidirectional aerial is desirable and that a ground plane, using the car roof, is ideal. Enlarging on this point, a quarter-wavelength in Band II is only 2½ feet, a dimension common to many features of a car body. Because of reflections, and its asymmetrical mounting, a wing aerial must have most unfortunate and pronounced directional properties, making it quite unsuitable for v.h.f. reception in any but the strongest signal areas.

Good sensitivity coupled with fading in strong signal areas and difficulty in tuning for best a.m. rejection all point to inadequate limiting action in the tuner. This would also account for the troubles experienced with interference suppression

Mr. Crossland mentioned noise picked up inside the receiver as another difficulty; the avoidance of multiple earthing in the receiver and the use of a remote power supply unit together with the filters I recommended have made further precautions unnecessary in my experience.

Using a Jason tuner (fringe area model) I have had no interference suppression difficulties, nor has other traffic caused any bother. Certainly the only noise entering the receiver does so by way of the aerial, and then it is removed by the limiting circuits in all but weak signal areas. When demonstrating the receiver in South London an unfiltered vibrator pack was used with a considerable length of cable between the power supply and a.f. units. A filter was fitted on the a.f. chassis; even then noise caused no trouble. Subsequent removal of the filter to the vibrator end of the cable (as indicated in the article) has eliminated vibrator noise.

As for coverage of the country, there certainly are gaps, but in noise-prone areas (which coincide with the population centres covered by v.h.f. transmitters) the f.m. receiver is capable of far better performance than any a.m. receiver. The ideal is a combined a.m./f.m. receiver but no British firm makes one. On the Continent, where I have also used a v.h.f. car radio with satisfactory results (tuned usually to B.F.N.), combined receivers are made by many firms. They seem to find no difficulties with noise, the normal h.t. suppression being adequate in most cases.

Danbury, Essex. R. V. TAYLOR

Deeper Amplitude Modulation

WITH reference to recent correspondence in your journal commenting on the difference in modulation levels of British and French a.m. stations to the detriment of British stations, I would like to comment from another point of view.

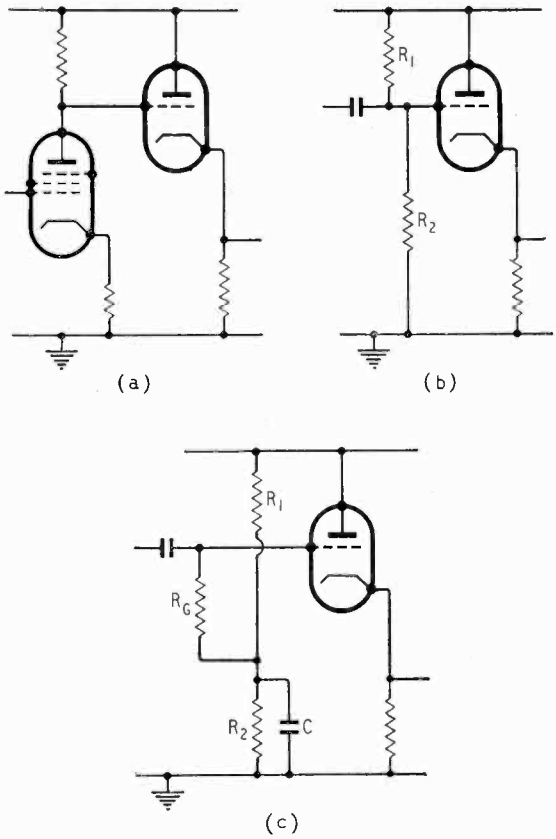
Here in Switzerland, French stations are notorious for their amount of sideband splatter. Even under good reception conditions, foreign (including British) stations are often unreadable because of French stations on nearby channels.

I have operated a receiver in Great Britain and know from experience that British a.m. stations are very free from sideband splatter. It would be a shame if this were spoilt for the sake of a few dBs' increase in audio level.

Geneva. F. KONOPASEK

Cathode-follower Biasing

IN his letter in the June issue, Mr. Bailey shows one way of translating my elementary circuit (which was intended merely to convey the essentials of a cathode-follower, and not to represent a practical one) into a physical reality. It is not the only way, and in particular, it is not necessary to have a negative supply line if response down to zero frequency is not required.



The whole subject was covered by "Cathode Ray" in the June, 1955 issue,* but this may be inaccessible to newer readers, and it is perhaps worth repeating some of the circuits discussed in it.

If the cathode-follower is driven from a valve, a simple direct coupling as shown at (a) is the ideal solution. Where this cannot be done, one is obliged to apply a positive bias between grid and earth in order to make possible the use of a normal-sized load resistance. Two ways of doing this are shown here. The method shown at (b) is the simplest, but it has disadvantages. If there is any ripple on the h.t. supply, a fraction of it is developed between grid and earth, and appears almost unattenuated at the output. Moreover, to preserve a high input resistance, R_1 and R_2 must be high resistances, running perhaps into tens of megohms. Practical high-value resistors have a reputation for instability, and if their resistances vary in this circuit the biasing of the valve is upset. Circuit (c) shows how these difficulties may be overcome. R_1 and R_2 may now be low resistances, and ripple can be removed by the capacitor C. R_G can have a high value: if it is unstable, the input resistance is affected, but not the biasing of the valve. Variations in input resistance are often unimportant provided that the latter is always above a certain minimum value.

An objection to these circuits is that they almost invariably lead to the use of grid resistances far in excess of the valve manufacturers' maximum ratings. If

* "Cathode Followers, With Particular Reference to Grid Bias Arrangements." *Wireless World*, June, 1955, p. 292.

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one uses the same high-value grid resistors in a normal amplifier, the anode current is often found to be different from the expected value. This is the result of small stray currents. For example, a high-resistance leak between anode and grid may set up an appreciable positive bias between grid and earth. Fortunately, in a cathode-follower, such voltages result in the development of opposing voltages across the cathode resistor. Their effect on the actual grid-cathode voltage is reduced by a factor of 1/(1-A) where A is the "gain" of the cathode-follower.

Croydon. G. W. SHORT

Self-balancing Push-pull Circuits

UNDER "Electronic Circuitry" in *Wireless World* of August 1948 J. McG. Sowerby showed how a high degree of negative feedback can be applied over three cascaded stages *via* an impedance common to the first and third cathodes. This gives the clue to self-balancing push-pull. A three-stage push-pull amplifier with feedback from the common output valves bias resistor to the common first stage bias resistor (*via* a large electrolytic capacitor to take care of bias voltage difference) gives such tight control of balance that the large cathode impedance of the Schmidt splitter is unnecessary, at least for reproduction of speech and music. As D. R. Birt hints in the last section of his June instalment, Class A working of the output stage is essential since the bias resistor is un-bypassed. The high gain from three stages enables heavy overall n.f.b. to be applied, and to give a very long time-constant to the middle stage grid coupling in the interests of l.f. stability (if not directly coupled) grid-leak bias—10MΩ with 0.1μF and earthed cathodes—can be used.

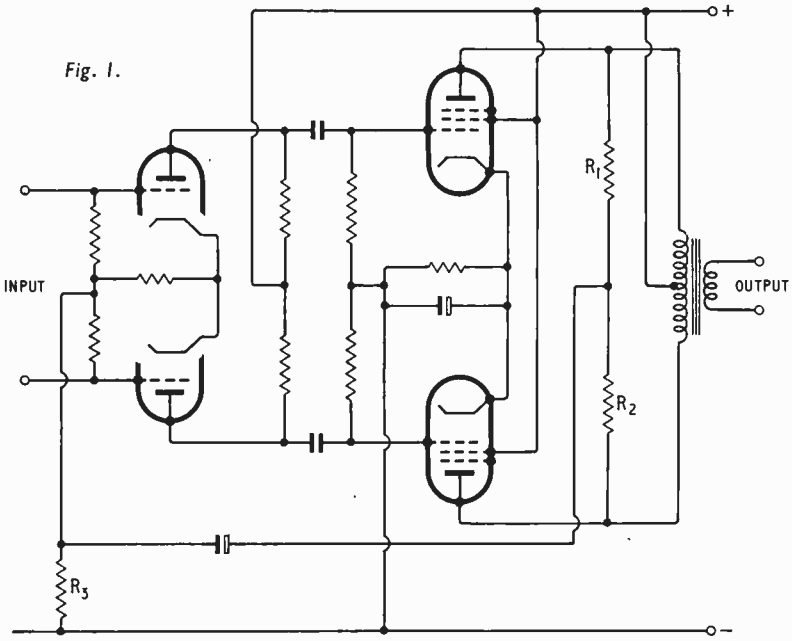

Fig. 1.

In any method of control by feeding back the error-signal such as this, the tightness of control depends upon the gain from the point of application of the error-signal to the point from which it is taken. An advantage of the above method over Mr. Birt's use of an amplifier in the first stage cathode circuit is that all valve stages are used gainfully as far as a.f. is concerned.

In a *two*-stage amplifier the error-signal can be fed back from the output anodes to the common cathode resistor of the input stage, but Mr. Birt's method of taking the error-signal from a resistor at the output transformer primary centre has some weaknesses. To obtain a substantial error-signal, R_7 (Fig. 5, May issue) must be large and of high wattage rating, and robs the output valves of precious h.t. voltage, and, I suspect, complicates the output loading. I would suggest the alternative in Fig. 1 herewith, R_1 and R_2 being selected for equality and together at least six times the optimum output load. R_3 in this case would be about equal to R_1 (the higher it is the greater the applied error-signal since R_1-R_3 and R_2-R_3 are potentiometers across the two phases of the output): normal Schmidt working of the first stage applies. Here, the output valves are not restricted to Class A if the bias resistor is properly bypassed.

To my pleasure at reading Mr. Birt's first instalment—because of my interest in his subject—was added surprise at reading his second, as I have done some work on cross-coupled cascode pairs also (and labelled them "Croscode"!). A point worth emphasizing is that the arrangement provides "free" phase-division without the Schmidt resistor or any other device. I have used two ways of providing automatic bias for the upper pair—Fig. 2—different again from Mr. Birt's method, not necessarily better.

However, as I see it, neither the self-balancing method in his first instalment nor that in this letter can be applied to the "Croscode". Assuming one of the upper valves has lower gain than the other, it will be seen that the error-signal applied positively to one side and negatively to the other, attempting to restore balance, is fed to *both* sides through the cross coupling, and the overall effect is exactly nil. Perhaps Mr. Birt's solution to this problem will appear in his promised design of a complete amplifier.

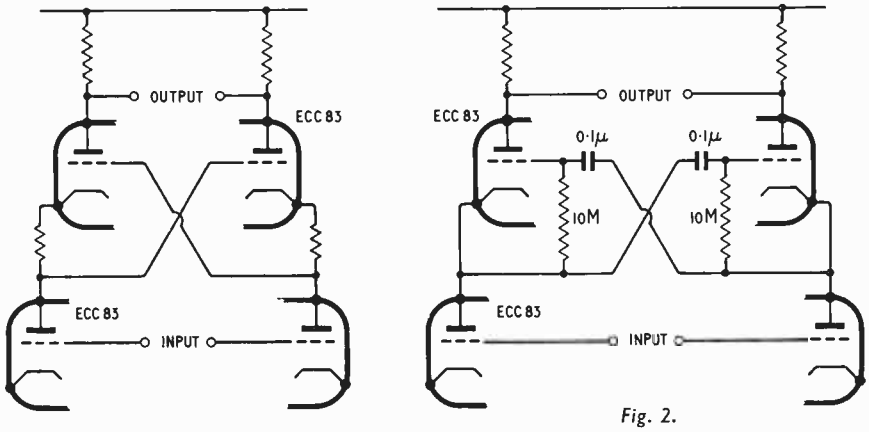

Fig. 2.

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For those wishing to try out the Croscode, I would mention that I found it necessary thoroughly to bypass the common bias resistor of the lower pair, or to earth the cathodes directly with grid-leak bias, to prevent l.f. instability.

Walsall, Staffs. STANLEY MAY

The author replies:—

I have read with interest Mr. May's letter, and I should like if I may to make some comments about the suggestions he has made.

An impedance common to the input and output cathodes of a triple does indeed provide control of the output stage balance. Since the resistance to earth of the input cathodes is that of the output stage cathode resistor (100Ω) no coupling takes place within the input stage, and all the drive to the earthed-grid triode of the input pair has to be developed by the out-of-balance output stage current. This drive (and the unbalance) increases if negative signal feedback is taken to the "earthed" grid. As Mr. May states, the degree of balance is proportional to the total gain between the cathodes, but the condition of perfect balance cannot arise, unless there is cross-coupling within the amplifier. In practice, it is difficult to achieve a very large loop gain and sufficiently low phase shift, because three h.f. time-constants are involved, and the cut-off frequencies of two of these (the first and second stage anode circuits) are comparable when maximum gain is realized in each stage. The performance is therefore inferior to that of the multi-loop systems previously discussed, where less overall feedback is required for a given degree of balance and where the cascode anode time-constant provides the dominant phase lag at high frequencies. It is perhaps worth pointing out that if comparable balance is obtained by employing a common cathode resistor in the middle stage of the triple, together with favourable component tolerances, then the earthed-grid triode becomes redundant as far as signal amplification is concerned.

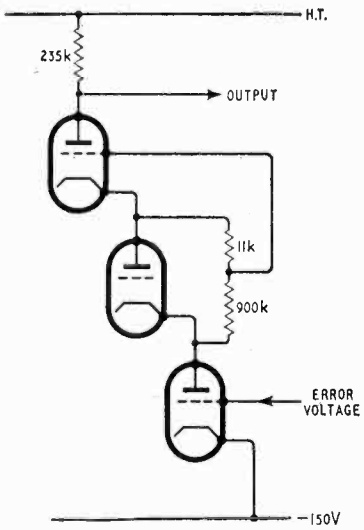
Error voltage feedback, as distinct from any form of signal feedback is restricted to Class A operation; whether this feedback involves many stages or is provided over the output stage only by an un-bypassed cathode resistor. This is because it is implicit in Class B operation that the increase in anode current in one valve cannot be instantaneously balanced by a decrease in the anode current of the other valve, the latter being zero.

Referring now to Fig. 5 (page 226, May issue) if V4 and V5 are typical 25-watt pentodes operating from 300V h.t., and $R_1 = R_2 = 220k\Omega$, then the error loop gain is 36 dB when $R_7 = 100\Omega$. The effective h.t. is reduced by approximately 5% and the wattage rating of R_7 is 2.5 watts. I suggest this is not too gloomy!

In Mr. May's alternative circuit (Fig. 1), even if one output valve is removed, there will be no error voltage at the junction of R_1, R_2 since the magnetic coupling in the output transformer will provide a balanced voltage across the potentiometer R_1, R_2. Thus R_1 R_2 and the electrolytic capacitor are redundant components! If the load impedance is constant the situation can be remedied at some cost by the inclusion of an L R network in the lead to the transformer centre tap.* Even then, we are not out of the wood, for if the source impedance at the input terminals is low compared to R_{g1}, the impedance "seen" by the junction of R_1 R_2 is not R_3, but R_3 in shunt with the cathode impedance of the input stage ($\frac{1}{2}g_m + R_k$)—about 1500Ω. Furthermore, inequality between the source impedances can influence the amplifier balance.

I am not quite sure what Mr. May has in mind in his penultimate paragraph, because it is intentional that the error voltage should be fed in the same phase to both sides of the amplifier.

The self-balancing methods discussed *can* be applied to the circuit of Fig. 11 (page 284, June issue). I think



perhaps the source of confusion is the connection between the grid and cathode of the upper valve in the push-push equivalent circuit shown in the accompanying diagram. The upper valve does not contribute appreciably to the error loop gain, but it should be remembered that the middle triode will not provide more gain because of its increased load. The measured error loop gain from the point marked "feedback" in Fig. 11 to the output terminals is 150 times at 400 c/s, which is generally sufficient to maintain the output stage balance to within 0.1%.

I should like to point out that a cross-coupled cascode circuit is inherently stable, and that it is not necessary to decouple any common cathode resistance. Any time constant in this part of the circuit can only cause instability when it forms part of a feedback loop (intentional or otherwise), involving at least two further time-constants.

In conclusion I should like to point out that the grid current bias which Mr. May favours can cause considerable distortion if the source impedance is high.

D. R. BIRT

* *Electronic Technology*, Jan. 1960, p. 41.

Standing Wave Ratio

I NOTE with dismay that in his article in the June issue, Mr. J. Robson elects to use the "American" rather than the "British" convention regarding v.s.w.r. "as the use of this convention appears to be increasing." I hasten to add that my dismay arises from no spirit of jingoism but merely from a feeling that confining a variable to the range 0 to 1 is a rational procedure followed in many "normalization" processes whereas to let it "roam" in the wilderness between 1 and infinity smacks of rank carelessness. And "Cathode Ray" in his current essay on hyperbolic functions admits that the world in which x/r is less than unity is more familiar than its "imaginary" counterpart.

However, there is one other somewhat analogous case arising also most commonly from transmission line problems, namely the impedance chart. The Cartesian form of this chart is rarely used for the very good reason that complete coverage of the impedance plane would require an infinite sheet of paper. Instead we use the polar form or Smith chart in which all passive impedances are constrained within a finite (unit!) circle. Why not apply the same criterion to v.s.w.r? After all, we do sometimes wish to plot v.s.w.r. against some variable or other and in spite of the possible indication to the contrary by the length of this protest, my supply of paper is strictly finite.

North Baddesley, Hants. L. C. WALTERS

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Transistor Inverters and Converters

I—Basic Principles of the Ringing-Choke System

By M. D. BERLOCK,* Grad. I.E.E., and H. JEFFERSON,* M.A.

PASSIVE methods of storing and of generating electrical energy deliver it in the form of a unidirectional current which, in the most efficient systems, is produced by units having a nearly constant potential difference at their terminals. This ideal of a fixed electromotive force and zero internal impedance is characteristic of the well-established primary and secondary cells and the new fuel cells, and is the aim of the makers of solar cells. The designer of the simpler forms of transistorized equipment is well content with energy sources of this kind, asking only for more watt-hours per pound, avoirdupois or sterling. The designer of valve equipment has always found this kind of energy source unsatisfactory except in very large installations, since he requires a number of different supply voltages and is constantly faced with the problem of balancing the advantages and disadvantages of single packs and multiple packs of batteries. The combined h.t. and g.b. battery of the older portable broadcast receivers was a typical compromise.

For most devices, of course, the supplies are derived from the a.c. mains and the use of a simple and efficient device, the transformer, permits a free choice of voltages. At the highest power levels mercury arc inverters may be used. It is when we turn to battery-operated equipment consuming power measured in watts, or hundreds of watts, that difficulties are encountered. This equipment may not necessarily be mobile equipment; it may be vital equipment which is normally operated by supplies taken from the a.c. mains but which cannot be allowed to stop operating if there is an interruption of supply.

Until recently the only available methods for converting the d.c. from a battery into a.c. for voltage transformation were by the use of vibrators or rotary converters. Both these methods rely on mechanical systems with moving parts: contact life in the vibrator and brush wear in the rotary converter are serious limitations in situations where skilled maintenance is not available. For low powers it has not been found possible to achieve high efficiencies.

The transistor inverter is bringing about a radical change in our views on battery operation: we may expect that the silicon controlled rectifier inverter will continue this minor revolution. It has now become practicable to construct efficient devices to generate, for example, 50mW at 100 volts from a 6-volt torch battery or 100W at 230 volts, 50c/s, from a 12-volt car battery. Existing but expensive semiconductor devices extend the range up to perhaps a kilowatt.

To the electronics engineer these semiconductor inverters, for generating a.c. from d.c., and converters, which include a voltage transformation and rectification, are particularly attractive. By conservative design he can assure himself of an extremely high reliability, limited only by factors with which he is already familiar. Precautions and protective techniques are those required for the remainder of the equipment and the inverter is the same kind of thing as the rest of the system so that it marries well into it. Furthermore the equipment designer can either design the inverter himself or, if he buys from another manufacturer, can understand exactly how it works. Rotary converters are regarded by most electronic engineers with all the doubt and suspicion reserved by rotary machine designers for electronics.

Three basically different types of transistor inverter appear to be in use. One of them, the class-B (or class-C) oscillator seems to us to be of little special interest: it is not a particularly efficient system and it wastes its power where it can do most harm, in the transistors. Its merit is that the output is sinusoidal.

The two types of inverter which have attracted most attention are the ringing-choke system and the transformer-coupled inverter. The latter, which has several variants, is probably the most important and will be discussed in detail in later articles. The remainder of this article will be devoted to the ringing-choke inverter.

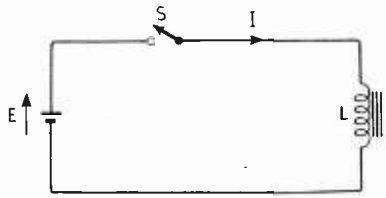

Fig. 1. When the switch is opened a high voltage appears across L.

We must begin by saying that the ringing-choke inverter, as such, is probably almost useless. In all the applications which we can see the ringing-choke system is used with a rectifier to provide a d.c.-d.c. conversion: the reasons for this will appear in the analysis. We must next say that we cannot see any particular reason why the choke should ring, in the sense indicated by T. R. Pye in *Electronic and Radio Engineer* for March 1959. It would appear to be more correct to describe the circuit as a blocking-oscillator inverter (or converter) when, as is usual, it is self-driven and to describe the corresponding device with separate drive, which as far as we know has not been used, as a pulsed-choke system.

In order to understand the operation of what we shall now call the blocking-oscillator converter it is necessary to build up the circuit piece by piece. The mode of operation of these circuits is so different from the conventional sinusoidal circuits that any

* The Phœnix Telephone & Electric Works Ltd.

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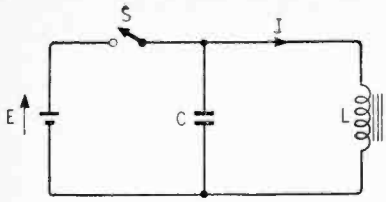


Fig. 2. The presence of C reduces the voltage appearing when the switch is opened.

attempt at short cuts can lead the unwary into difficulty. To start off, therefore, we consider the circuit shown in Fig. 1. When the switch is closed there is initially no current, but the current in the loop increases steadily, satisfying the equation.

$$I = \frac{1}{L}\int E\,dt \quad .. \quad .. \quad (1)$$

or, in fact

$$I = E/L\,.\,t \quad .. \quad .. \quad (2)$$

After some time t, then, the inductance is storing an amount of energy

$$W = \tfrac{1}{2}LI^2 = \tfrac{1}{2}EIt = \tfrac{1}{2}E^2t^2/L$$

If now the switch is opened we are faced with an intolerable situation. We may very conveniently refer to the simple mechanical analogue of a mass L moving with velocity I, which has kinetic energy $\tfrac{1}{2}LI^2$. Opening the switch brings it to rest *instantly*, which is getting close to the irresistible mass hitting the irresistible object. The old-fashioned induction coil for providing electric shocks and the coil used in motor-car ignition systems show what happens. For analytical purposes we must now put a capacitance in parallel, as shown in Fig. 2. When we open the switch the energy stored in the inductance has somewhere to go: in our mechanical analogue the object has become a spring. The capacitor has initially stored energy $\tfrac{1}{2}CV^2$ but when the switch is opened the voltage swings to some value V_1 which satisfies the equation

$$\tfrac{1}{2}CV_1^2 = \tfrac{1}{2}CV^2 + \tfrac{1}{2}LI^2$$

The energy is then passed back again, the system ringing until the unavoidable resistances have dissipated it.

Instead of putting a capacitor across the choke let us connect a rectifier and a resistor R, as shown in Fig. 3. The added components have no effect on the current build-up, because the rectifier isolates the resistor. The switch is again opened when the current has reached a value I, given as before by equation (2). The "magnetic inertia" keeps I flowing and it can now flow through the resistor by the path shown dotted in Fig. 3. Consequently Y must be positive with respect to X and the instantaneous voltage reached will be

$$V_{yx} = IR.$$

The current will now decay exponentially in the usual way until all the stored energy has been dissipated in the resistor.

The sudden jump from the situation in which Z is positive with respect to Y, switch closed and diode backed off, to the situation in which X, and thus Z, is negative with respect to Y will be slowed down by any stray capacitance, the capacitance shown as C in Fig. 2. If, in addition, we add a capacitance across R and make this (C_1 in Fig. 4) large enough to hold the voltage constant while we repeat the switching operation quickly, we will get the following sequence of operations:

(a) switch closes, current in L grows linearly,
(b) switch opens,
(c) current in L flows into C, charging it until E_{zy} exceeds E_1,
(d) diode conducts, current flows into C, until the linear fall in current through L produced by E_1 (this satisfies eq. 2) brings the current to zero, when,
(3) The diode cuts off, leaving C and L to oscillate in the usual damped sinusoid.

This sequence is shown in Fig. 5.

If now we arrange that when E_{zy} goes positive (or reaches zero or a small negative value) the switch is closed we can produce condition (a) again, and if we arrange to reopen the switch at some chosen current we produce (b). The system is then a self-maintaining one. It is very important to notice that it is basically a two-stroke system, drawing energy from the battery when the switch is closed and passing it on to the load when the switch is open. This is, of course, a consequence of the introduction of the diode and it is for this reason that the circuit is used in converters rather than inverters. The other reason is that the two-stroke mode of operation gives a waveform which is thoroughly inconvenient for use in any a.c. device.

The switch used is, as you might expect, a transistor. In Fig. 6 we have the basic circuit with the battery E in series with the inductance L_1 and the collector-emitter path of the transistor switch. Bias, in this rudimentary circuit, is applied to the base through L_2 from a bias battery E_b. When first switched on this bias E_b is enough to allow some collector current to flow, and the growth of this current produces additional bias across L_2 to keep the transistor conducting. The current in L_1 therefore rises linearly and obeys equation 2. Meanwhile the voltage across L_2 is proportional to the

Fig. 3. The energy stored in L is now transferred to R when the switch is opened.

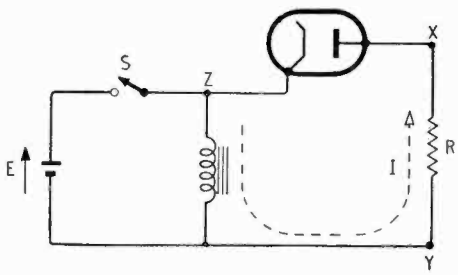
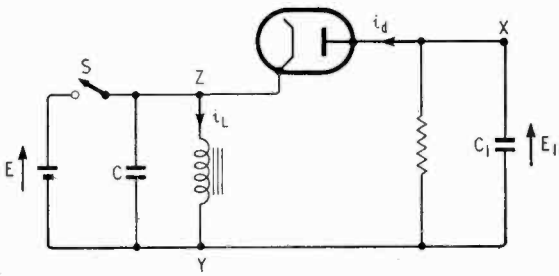


Fig. 4. With these additional capacitors we get the waveforms shown in Fig. 5.



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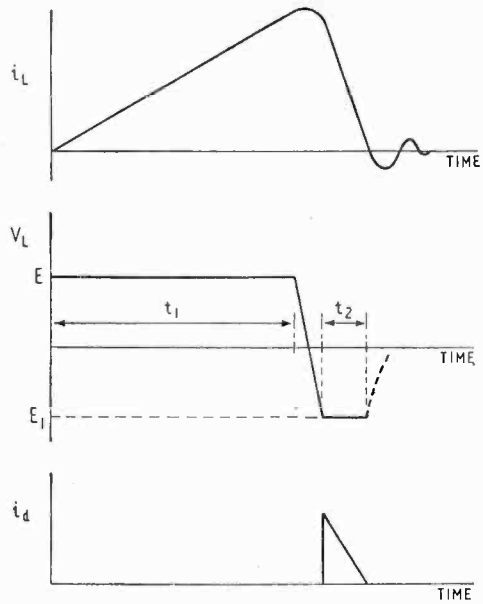

Fig. 5. The conditions in the circuit of Fig. 4. The charging stroke lasts for time t_1 and the discharging stroke for time t_2.

rate of change of the current in L_1 and is thus constant with a value

$$E_{L2}=(L_2/L_1)E.$$

Neglecting the effect of E_b, I_{co}, the internal resistance r_b and other oddments, which only make the equations more elaborate, this voltage E_{L2} will drive a current I_b into the base, where

$$I_b = E_{L2}/R_b$$

In turn this base current makes available a collector current of

$$I_c = \beta' I_b.$$

As the current through L_1 grows the collector-emitter path passes it freely so long as it is below this available value I_c but when the current reaches I_c it cannot increase any more. We have travelled up the diode line of the transistor to the knee and now move round the knee to the high impedance region. The current now increases only very slowly through L_1 and, in consequence, the voltage E_{L2} falls to a low value. Now the base current I_b is reduced and even the existing limit of I_c is too much for the transistor so that the current actually starts to fall and, in doing so, produces a reverse bias at the base. The transistor is well and truly cut off.

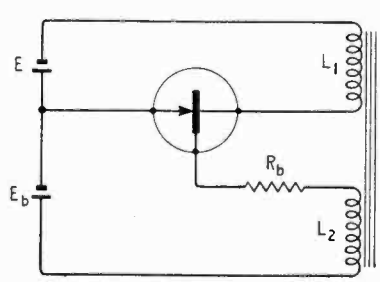

Fig. 6. The basic blocking oscillator.

The sequence described above is the charging stroke in which energy is fed into L_1 through the switch and the operation terminated by opening the switch. We now add to Fig. 6 a diode, a capacitor and a load resistor across L_1 so that the discharge stroke, which is quite independent of the transistor, can follow the pattern already described.

Towards the end of the discharge stroke the diode cuts off under conditions which depend on the reactance structure. The detailed analytical techniques used for pulse-generating blocking oscillators do not seem to have been found necessary by any converter designers. It is usual to consider that the circuit would settle in a damped oscillatory mode if the first overswing did not drive the transistor into conduction, but if the value of bias is suitably chosen an over-damped settling would bring the system into the region where a new charging stroke could begin. The oscillatory mode is probably advantageous because it speeds up the transition phase and produces a more definite switch-on in the transistor. It goes without saying that since the storage and delivery of energy is in the magnetic flux through the inductor core a third winding may be used for the diode and load circuit.

One very important factor has not yet been mentioned explicitly. We have seen that the voltage across L_1 will shift violently until the diode conducts. If the swing needed is too great the voltage actually applied across the transistor may be sufficient to destroy it. This represents one of the most important factors in design.

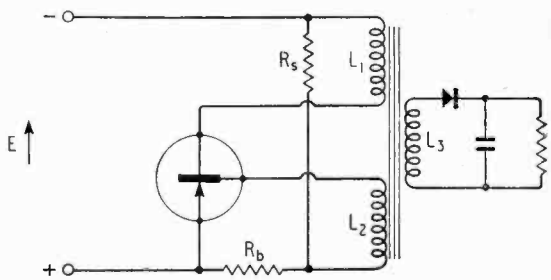

Fig. 7. The practical converter.

We may now turn to the problem of establishing a practical design. The circuit is shown in Fig. 7 in which the base bias battery is now replaced by a voltage divider R_s, R_b. The three windings of the transformer have inductances L_1, L_2 and L_3 with corresponding turns ratios $N_1 : N_2 : N_3$.

The first step is to define the requirements, an output power W at some voltage V to be obtained from a supply E. From experience with similar converters we make a guess at the efficiency which will be obtained: this depends on a number of factors which are discussed below and for purely arithmetic (and typographical) reasons we shall choose the very low value of 50%. We need then to draw a total power of 2W from the supply. For 83% efficiency the figure will be 1.2W and in a practical, rather than tutorial, problem this might be more correct.

This power of 2W is drawn in a series of pulses with spaces between them. If the pulses last for a

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time t_1 and the spaces for a time t_2 the power must all be drawn at the rate of

$$2W\,(t_1 + t_2)/t_1 \text{ watts}$$

The average input current must therefore be $(2W\,(t_1 + t_2)/t_1)/E$ and, as this current has the form of a series of triangular impulses, the peak current must be twice this, or $(4W/(t_1 + t_2)/t_1)/E$

The voltage which appears at the collector during the energy discharge stroke is equal to

$E\,(1 + t_1/t_2)$ and also, of course, to

$$V = (N_3/N_1)\,E\,t_1/t_2$$

We know from the transistor data that we may not apply more than E_{pk} to the transistor, so that, working to the limit (and the wise designer will put in his own safety factor)

$$t_1/t_2 = (E_{pk}/E) - 1$$

This number can now be substituted in the expression for current,

$$I_{pk} = \frac{4W}{E}$$

and this can be compared with the permitted figure for the transistor already tentatively chosen.

Assuming all is well the value of β for the transistor at this current, or the value of I_b required (some transistor manufacturers seem rather chary of disclosing data on their products) is now found. Then we must make

$$I_b = I_{pk}/B = (N_1/N_2)/R_b.$$

We would wish R_b to be very small, so that minimum energy would be diverted into it, were it not for the fact that then R_s would need to be small too, so that the small forward bias of about 0.15 to 0.2 volt might be developed. A compromise is to allow the R_s, R_b divider to dissipate a few per cent of the converter energy. The value of R_b is then known and the equation above gives the turns ratio N_1/N_2.

Only one factor remains to be decided: we have determined the turns ratio N_3/N_1 and the turns ratio N_2/N_1. What value of inductance, how many turns, should we use? The choice of operating frequency is involved here too, and the criteria to be used are difficult to define precisely in a simple survey. One limitation is set by the short pulse t_2. The edges of this should be fairly square, occupying, let us say, less than 0.1 t_2. The repetition frequency must be chosen so that $10/t_2$ is less than the highest frequency the transistor will handle: we know that $t_1/t_2 = r$, so that $(t_1 + t_2) = (1 + r)\,t_2$ and as

$$f_{rep} = 1/(t_1 + t_2) = 1/(1 + r)\,t_2$$
$$f_{rep} < f_{max}/10\,(1 + r).$$

The establishment of a minimum frequency of operation is associated with the transformer design. We know that

$$f_{rep} = 1/(t_1 + t_2) = r/(r + 1)\,t_1$$

and that, following from eq. 2

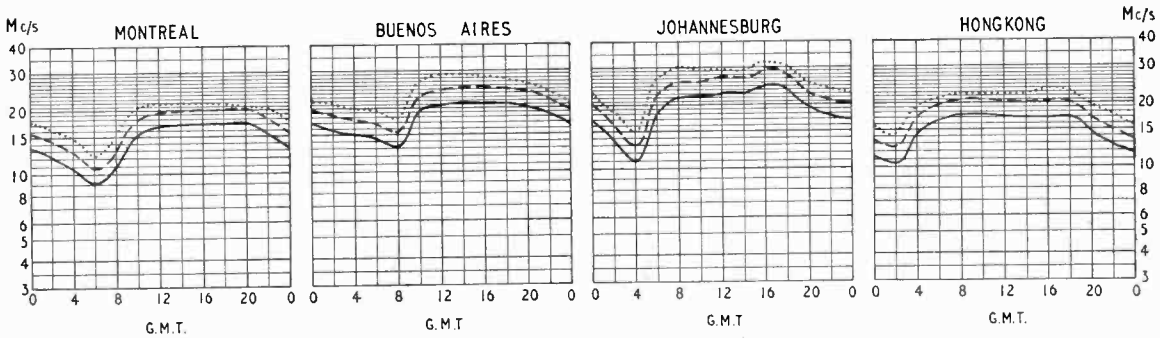
$$t_1 = L_1\,E/I_{pk}$$

We thus need a transformer having one winding with an inductance L_1 which will not be too near saturation at a current I_{pk} and which has a resistance small compared with E/I_{pk}. Having made a tentative choice, we check that the resulting frequency satisfies the inequality given earlier.

For a close design we must examine the losses which are introduced by the various elements and attempt to minimize them. There is a loss in the transistor during the conduction period when the collector voltage is low and equally important losses during the transitions. Some power is necessarily fed into the base circuit. Core and copper losses in the transformer are probably the main source of inefficiency. The rectifying diode is more wasteful than one would expect, because it operates at high current for a short time. In a completed design both the overall efficiency and the transistor losses alone should be calculated, because it is essential to ensure that no overheating takes place.

SHORT-WAVE CONDITIONS

Prediction for August



THE full-line curves indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during August.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

•••••••••• FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED MEDIAN STANDARD MAXIMUM USABLE FREQUENCY

——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

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Inverted Triode Voltmeter

NOVEL CIRCUIT USING A TRANSISTOR TO GET GREATER SENSITIVITY

By R. B. ROWSON, B.Sc., A.M.I.E.E. and A. P. WILLIAMS, A.M.I.E.E.

THE inverted triode voltmeter, as shown in Fig. 1, is occasionally mentioned in the literature as having a very desirable high input impedance but as being suitable only for very high voltage measurements. This last-mentioned disadvantage we have sought to overcome, and the simple instrument described will give full-scale deflection for only 0.3 volts input. The circuit uses a combination of valve and transistor and takes advantage of the best features of each, i.e. the high input impedance of the valve and the current amplification properties and low output impedance of the transistor.

The first reference to the inverted triode voltmeter known to us is a paper by Terman[1], who mentions how it can be used for operating an oscillograph without taking current from the source. The inverted triode is thus a power amplifier and can also be used as a voltage amplifier if a high ratio* step-up transformer is put in the grid circuit. This is possible because the output impedance is low.

In operation a negative or positive potential applied to the anode (Fig. 1) causes a decrease in grid current and thus a reduction in the reading of the meter in the grid circuit, the highest grid current flowing when the anode potential is approximately zero. Intuitively a negative anode potential can be visualized as forcing the electrons back into the cathode, thereby reducing the grid current. If the anode is made positive it draws electrons through the grid and thus again reduces the grid current.

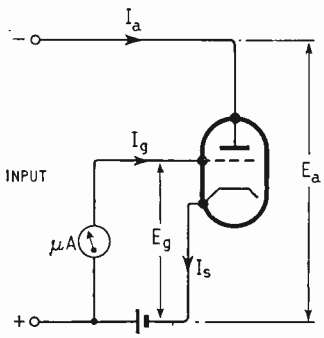

Fig. 1. Basis of the conventional inverted triode voltmeter.

More precisely we can consider the equation originated by van der Bijl[2], which gives the electron current I_s in terms of the grid and anode potentials, i.e.

$$I_s = f[E_g + (E_a/m)] \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

neglecting the term covering the intrinsic potential difference between cathode and grid-anode system. In this equation m is similar to the usual μ and can be shown to be C_{ak}/C_{gk} and thus the inverted triode can be looked upon as acting as a capacitance divider. While E_a is sufficiently negative no current flows to it and thus $I_s = I_g$, and under these conditions one can readily see that a negative E_a results in a decrease in grid current, if E_g is held constant.

If E_a is made positive the condition is more complex, I_a ceases to be zero and the split-up of I_s is confused by secondary electron effects. It has been shown by Chaffee[3] that lines of constant emission current plotted on axes of E_a and E_g have discontinuity for low positive values of E_a and E_g. Spangenberg[4] shows that whilst E_a is less than E_g, I_g is greater than the primary electron current, but if E_a is greater than E_g it is less. Based on an empirical law he finds

$$I_g = I_s/[1 + d(E_a/E_g)^b] \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

"b" is 0.5 if $E_a/E_g > 0.8$ or 2 if less, and "d" is the current division factor, i.e. I_a/I_g when $E_a = E_g$.

By substituting for I_s from (1), an expression in measurable factors is obtained. Unfortunately "d" changes rapidly for small values of $E_a = E_g$ due to the change in position of the virtual cathode. The numerator of (2) changes very slowly with changes in E_a if m is high. For example, a tenfold change in E_a may only result in a 7% change in the numerator. If $E_a = 0$, the denominator is a minimum and thus I_g is at its maximum. For increasing positive or negative E_a the denominator increases quite rapidly and thus I_g falls in both cases. As the particular virtue of the inverted triode voltmeter is its high input impedance it is desirable to avoid anode current and in the arrangement described later a minimum bias has been built into the circuit.

As $I_a = 0$ for negative values of E_a and as I_a has a value for positive E_a the valve has a rectifying action. This can be made use of to measure a.c. by inserting a capacitor in the anode lead (capacitance somewhat greater than C_{ak}). This charges up when the impressed wave goes positive and thereafter current flow is zero.

Having considered the general theory, it is useful to examine the various practical circuits which have been suggested. Ref. 5 describes a circuit using a special valve (Westinghouse, RH507) having an internal earthed wire touching the inside of the glass envelope to drain away static charges, and draws attention to the need of constant filament current. It also shows that the maximum sensitivity occurs at around $I_a = 0$. With this design currents of 10^{-14} amp are measurable. In contrast, the circuit described by Kepferberg[6] uses a 211-D and was designed for voltages up to 5kV and has an input impedance of 5×10^9 ohms.

Several engineers have used a slide back arrangement; Foster[7], for example, puts a voltage E_b on the anode (positive to anode) and finds the grid voltage for zero or known I_a. He then puts the voltage to be measured, E_x, in series with the battery and anode, and adjusts the grid voltage to give the same I_a as before. In this case

$$E_x = (E_b \,.\, E_{g2}/E_{g1}) - 1$$

This method is referred to by Hund[8] and is used by

* Greater than the value m which appears in equation (1) and is defined just below it.

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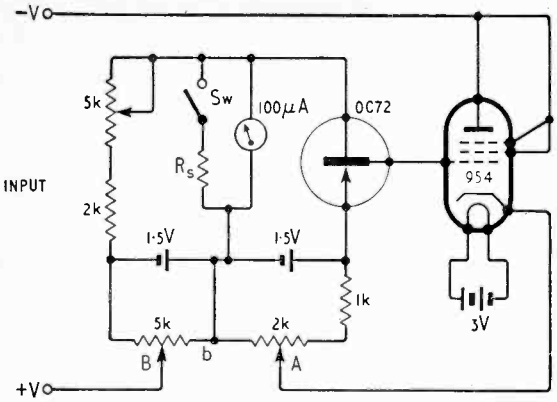

Fig. 2. Improved circuit incorporating a transistor. Battery switches are not shown.

Yuan.[9] To prevent splash current Yuan puts a 7.5-volt battery in the anode lead. He also gives graphs showing that I_g/V_g is a curve but V_g/V_a is a straight line, the moral being that I_g should be kept constant.

One way of overcoming this lack of linearity was mentioned above; another, due to Scheenburger[10], is to use a tetrode, returning the screen to the cathode via a high resistance, again resulting in lack of sensitivity. Scheenburger's instrument had an input resistance of 10^{13} ohms, tested by charging the anode with a comb run through the hair and finding the time for the volts to drop to 63%. Knowing the anode/cathode capacitance, the resistance can be calculated.

One difficulty of the inverted triode voltmeter is the very low grid current to be measured needing a very sensitive meter for a low reading instrument. A way of overcoming this is given by Genin[11], where the measuring valve, a pentode EL8, is the upper part of a cascode pair. Here the grid current is fixed, the cathode of the top valve (i.e. the anode of the lower one, a 6AU6) moves, and the change in voltage is applied to a cathode-coupled pair.

It will be seen that what is required is a method of maintaining the grid current relatively constant and of amplifying the very small changes in voltage which occur, so that a relatively robust meter can be used. It is felt that the circuit shown in Fig. 2 meets these conditions. The input impedance is very high, no noticeable difference in reading being observed when a 50-MΩ resistor is placed in series with the incoming voltage. The circuit, using a 954 valve which can be bought very cheaply and has very well insulated electrodes, gives in effect an electrometer for a very moderate cost. As the electron current required is small the heater can be run at half, or even less, voltage, which also has the advantage of reducing secondary emission from the grid.

With the shunt R_s (say 1/20 R_m) across the meter and no backing-off current (the backing-off current is merely to balance the static collector current through the meter), potentiometer A is adjusted to give a reading of about 1mA to bring the sensitivity of the transistor to about optimum and to give a reasonable grid current. The backing-off current is then increased to give about zero reading, when the shunt can be opened. Either control is then slightly adjusted to give full-scale reading.

For some purposes potentiometer B, taking the positive end of the incoming voltage, is adjusted so that the same reading is observed when the incoming terminals are either short-circuited or open-circuited; depending on the valve it may be necessary to connect end " b " of potentiometer B to the slider of A instead of to the junction point of the batteries to achieve this condition. Application of a positive voltage to the anode reduces the reading. As described, 0.3 volts give a change of 100 microamps in the reading of the meter. A " charged " fountain pen held about one foot away drives the pointer off-scale. In view of the sensitivity, for general use the terminals could be shunted by a 50-MΩ resistor.

To read a.c. Medina[12] used a rectifier to charge a polystyrene capacitor, which was connected across the incoming terminals, thus obtaining a peak voltmeter. He used a 6V6G, removing the base and painting the envelope with methylchlorosilane to reduce leakage further. By this means the charge was retained in the capacitor and readings could be taken some time after the phenomenon being measured had occurred. A probe incorporating a silicon rectifier and a 100-pF or less capacitor gives satisfactory results with the present instrument. Alternatively, having set B to give no change in reading, a.c. can be applied directly via a 10-pF capacitor.

" Anode "	" Grid "	Earthed Screen†	D.C. Range
$a+g_3+g_2$	g_1	—	0—0.3 volts
$a+g_3$	g_1+g_2	—	0—50 „
$a+g_3$	g_1	g_2	0—75 „
a	g_1+g_2	g_3	0—600 „

† In the instrument described there is no appreciable difference whether the earthing is direct or via a resistor.

In order to reduce leakage currents to a minimum it is advisable to use a ceramic valve holder and to bring the leads for the anode, suppressor and screen grid through the case via ceramic bushes. Higher voltages can be measured by connecting the valve electrodes to form the effective grids and anodes in the manner indicated in the table. Line 1 of this table corresponds to Fig. 2, and is the most sensitive arrangement.

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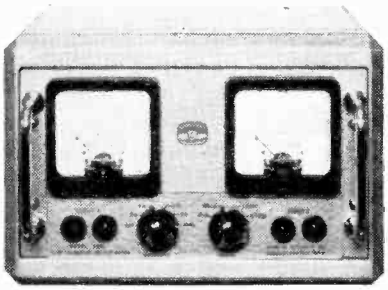
Manufacturers' Products

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Stereo A.F. Power Meter

THE new Amos of Exeter Model 158 comprises two of their Model 156 a.f. output meters. These are housed together in a single cabinet and have their impedance and power-range selection switches ganged together. The four power ranges give full-scale deflections with inputs of 10mW, 100mW, 1W or 10W (the meters are also graduated in dB), and the input transformer can be matched to impedances of 3, 5, 7.5, 15 or 600Ω. The accuracy is ±0.5dB from 10 to 20,000c/s: the two channels are matched to 2%. The Model 158 costs £34 10s (carriage paid in U.K.), and is manufactured by Amos of Exeter Ltd., of Weircliffe Court, Exwick, Exeter.

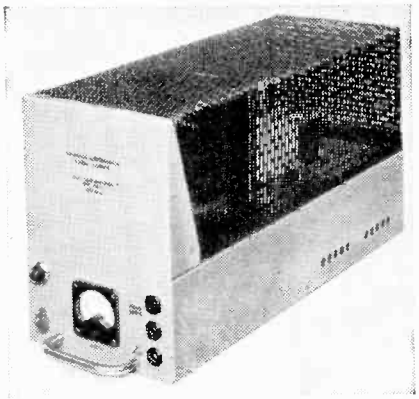


Amos of Exeter twin-channel a.f. power meter.

H.F. Wide-band Amplifier

APERIODIC amplification over the frequency range 1Mc/s to 30Mc/s is provided by a wide-band amplifier, Type VM 30, recently developed by R. H. Minns Electronics, of The Lower Mill, Kingston Road, Ewell, Surrey. An output of 15 watts into an impedance of 100Ω is obtained for frequencies up to 26Mc/s with 1 volt applied across the 100-Ω input circuit. The output falls to 10 watts at 30Mc/s for the same input. Models are available for various input and output impedances, co-axial or balanced. Amplification is carried out in three stages, the last two using Mullard QQVO6-40A valves. Inter-stage coupling throughout is by means of a new range of wide-band transformers developed by R. H. Minns Electronics. The equipment operates from the mains supply, through a germanium rectifier. Several of the amplifiers are being used by the B.B.C. to provide drives for h.f. broadcast transmitters.

A wide-band distribution amplifier, Type VM 40, is also available, enabling up to three of the Type VM 30 wide-band amplifiers to be fed from a single source. There is a voltage gain of 3:1 between the input and each output of the distribution amplifier.



Wide-band amplifier for communication frequencies by R. H. Minns Electronics.

Tunable Mobile Aerial

IN mobile v.h.f. radio systems transmitters and receivers frequently operate in channels too widely separated for the average whip aerial to operate at best efficiency and a compromise aerial has to be employed. With the new "Avel Mobile Antenna," however, maximum efficiency is obtained by automatically tuning the aerial to the transmit and receive frequencies as required.

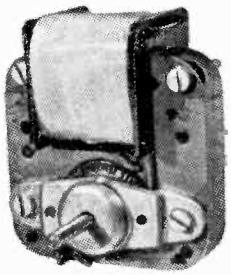
The tuning unit, which is illustrated, forms the base for the usual vertical aerial and it incorporates trimming capacitors and a coil, the inductance of which is changed, as required, by a solenoid-operated dust-iron core. By this means the aerial can be tuned correctly and in turn to any two frequencies up to 15Mc/s apart. The unit is built to withstand severe vibration and is protected by a toughened fibre-glass moulding. While designed initially for use on motorcycles operating in the 80-100Mc/s band, models are becoming available for frequency bands between 30 and 174Mc/s for use on cars, vans and launches, and for 6V, 12V or 24V operation.

The makers are Aveley Electric Ltd., Ayron Road, Aveley Industrial Estate, South Ockendon, Essex.

Small Induction Motor

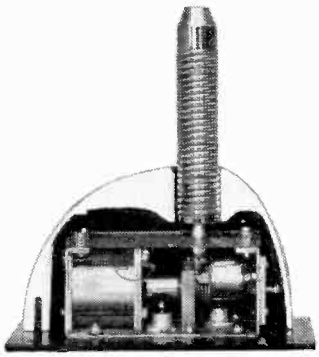
A COMPACT, fractional-h.p. induction motor, intended for use in tape recorders, record players and electronic equipment generally, has been introduced by R. B. Pullin and Co. Ltd., Phœnix Works, Great West Road, Brentford, Middlesex. It is a shaded-pole, squirrel-cage type with the rotor supported in self-aligning bearings embodying oil-impregnated lubricating pads.

The working voltage is 200 to 250V, 50c/s and the



Above: Pullin shaded-pole fractional-h.p. induction motor.

Below: Aveley remotely tuned, mobile-aerial unit.



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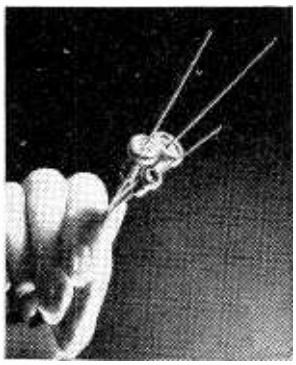
starting torque is greater than 60gm cm. A no-load speed of 2,900 r.p.m. is attained falling to a minimum of 2,600 r.p.m. with a torque of 80gm cm and 230V input. Under these conditions the input current does not exceed 0.2A, and the maximum power output is 0.003 h.p. (2.5W). The maximum temperature rise without a fan is 50°C.

Motors are available with the driving shaft at one end (Type ASP1), or with extended shafts at both ends (Type ASP2). The price is 15s.

New Tantalum Capacitors

HAVING concluded an agreement with the Fansteel Metallurgical Corporation of America the Plessey Company are now marketing the extensive range of tantalum capacitors made by the American firm.

The new range extends from 325μF at 6V to 1.75μF at 125V d.c. working and they are available in three



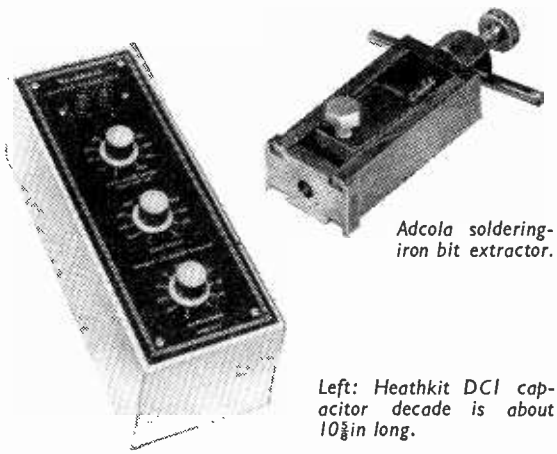
Examples of the three sizes of Fansteel Corp. tantalum capacitors marketed by Plessey.

sizes, the smallest measuring 15/32 × 5/16in and the largest 49/64 × 37/64in.

All three sizes are available with the alternative tolerances of −15 to +20% or −15 to +50% at an ambient temperature of 25°C, but they may be used up to 125°C (ambient) at reduced working voltages. Full details are obtainable from the Plessey Chemical and Metallurgical Division at Towcester, Northants.

Capacitor Decade Box Kit

THIS unit achieves the ten capacitance steps in each decade by switching a combination of four ±1% silvered-mica capacitors. With all switches at zero the residual capacitance is 18pF and the maximum of 0.111μF is reached in 100pF increments.



Adcola soldering-iron bit extractor.

Left: Heathkit DC1 capacitor decade is about 10⅝in long.

Costing £5 18s 6d in kit form the Heathkit DC1 capacitor decade box is rated at 350V d.c. and is available from Daystrom, Ltd., Two Mile Bend, Bristol Road, Gloucester.

Marine V.H.F. Radio Telephone

THE new Marconi "Argonaut" v.h.f. radio-telephone equipment provides a maximum of 50 working channels in the international maritime band of 156Mc/s to 163.4Mc/s. It is designed to enable ships to communicate on the frequencies assigned for emergency calling, port operations, public correspondence, inter-ship and private maritime use. It has received the British G.P.O. approval for these services.

Basically the "Argonaut" comprises two separate units, a control unit measuring 10¼in × 11½in × 6½in and incorporating loudspeaker, channel-selecting switches, microphone-telephone handset and all necessary controls. This unit is used for either local or remote operation of the transmitter-receiver which, with its power supply, is a separate unit measuring 36¾in × 20¾in × 7½in and may be installed up to 300ft from the control point.

The equipment operates on either 110V or 220V d.c. or 115V or 230V, 50-60c/s a.c. Maximum r.f. output is 20W (the limit under the Hague agreement) but a "reduced-power" switch permits a reduction in output to about 0.5W to be effected. Direct operation from 220V d.c. mains (without an internal power unit) is possible, and under these conditions an r.f. output of about 7W is available. Frequency modulation is employed.

Compact control unit of the Marconi "Argonaut" marine v.h.f. radio telephone.

The addition of a switching unit enables the equipment to be operated, including channel selection, from either one of two control positions. A "watch" unit may be added also to provide unattended monitoring of two independently selected channels. Duplex or simplex operation is possible.

Further details can be obtained from the Marconi International Marine Communication Co. Ltd., Chelmsford, Essex.

Soldering Equipment

THE extractor tool illustrated has been designed to facilitate the removal of worn and seized bits from Adcola miniature soldering irons. Normally the extractor is operated by hand, but for particularly stubborn cases of seizure it can be set in a vice and the extractor screw turned by an ordinary ⅜in spanner. Separate thrust plates and chucks to take the three normal sizes of bits, ⅛in, $\frac{3}{16}$in and ¼in, are available.

The combined protective unit and stand made for Adcola soldering irons has been redesigned and now embodies wiper and abrasion pads for cleaning the bit, also a handy reel of solder wire, all accommodated in the base of the unit.

Further details can be obtained from Adcola Products, Ltd., Gauden Road, Clapham High Street, London, S.W.4.

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Elements of Electronic Circuits

16.—THE TRANSITRON TIMEBASE

By J. M. PETERS, B.Sc. (Eng.), A.M.I.E.E., A.M.Brit.I.R.E.

THE transitron circuit has been previously dealt with, in the March, 1960, issue, in connection with the generation of rectangular waveforms, and its action as a triggered relay has been described. Slightly modified, it can be used as a freely running generator of sawtooth voltages, and such an arrangement, known as the Fleming-Williams circuit, is shown in Fig. 1. Before describing the action it will be helpful if some general properties of transitron-type circuits are outlined:—

(a) Under certain conditions the space charge existing between screen and suppressor grids can act as a "virtual cathode"; hence variations in suppressor grid potential can vary the anode current. When these conditions obtain, it is possible to regard the pentode as consisting of two separate triode valves. One triode is formed by anode, suppressor grid and "virtual cathode," the other by screen grid, control grid and true cathode.

(b) A reduction in anode voltage diminishes the anode current, increases the screen current and hence lowers the screen voltage.

(c) A reduction in screen voltage, however, reduces both anode and screen grid currents, so that the anode voltage rises.

(d) When anode current flows the screen current is low and the screen voltage is high. When anode current is cut off, screen current is high and screen voltage is low. These are the limiting conditions operating in a transitron circuit.

(e) With certain values of anode voltage and suppressor voltage, a rise in suppressor voltage causes a decrease in screen current and a rise in screen voltage. A typical static characteristic is illustrated in Fig. 3. A further rise is caused due to the external coupling between screen and suppressor and this action is cumulative. When the suppressor volts fall (over the same region of the characteristic) the screen voltage falls. This is again a cumulative action.

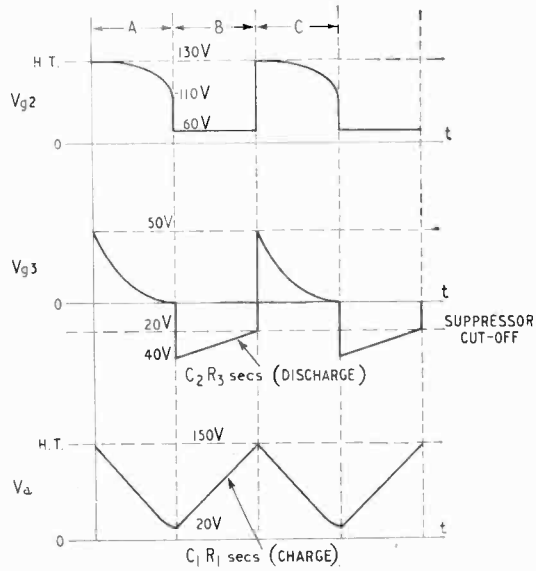

Fig. 2.

With these properties in mind, let us examine the sequence of events in the circuit in more detail.

Stage A

At the commencement V_{g3} is assumed to be positive, I_a is flowing and is larger than the C_1 charging current through R_1, V_a is falling and V_{g2} is at its maximum value. C_1 discharges rapidly and V_a falls. I_a, however, remains constant until the

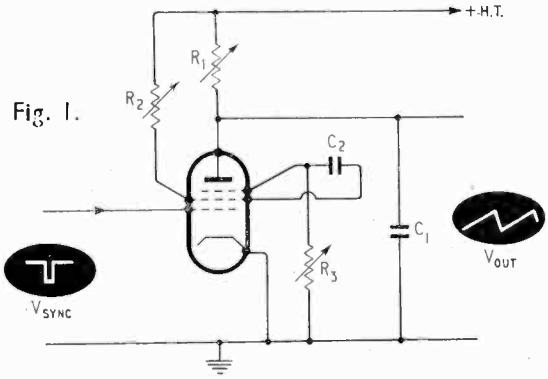

Fig. 1.

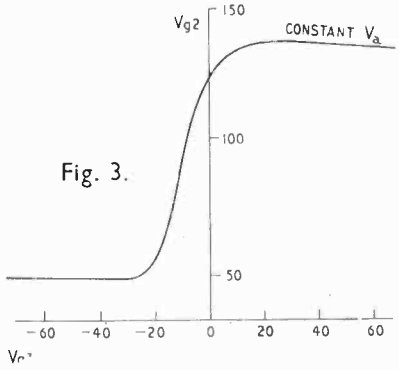

Fig. 3.

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"knee" of the V_a/I_a characteristic is reached and then it falls. V_{g3} is falling; ultimately a condition is reached when a "virtual cathode" starts to form between screen and suppressor grids. The fall in V_{g3} causes a fall in V_{g2} (*vide* suppressor volts/screen volts characteristics) and there is a further reduction due to the coupling circuit C_2R_3. I_a is finally cut off and the suppressor is driven beyond the suppressor cut-off bias.

Stage B

C_2 discharges through R_3 and the suppressor voltage starts to rise. V_{g2}, however, remains constant as the suppressor volts are still below suppressor cut-off bias. C_1 charges through R_1 and V_a starts to rise. Ultimately V_{g3} reaches suppressor cut-off and I_a starts to flow. I_{g2} drops as a result. V_{g2} rises, taking V_{g3} with it. I_a increases further, I_{g2} drops. The action is cumulative at the end of this stage until I_a cannot increase any further (the "knee" of the characteristic has been reached). By this time V_{g2} has taken V_{g3} well positive.

Stage C

The production of the large I_a causes C_1 to discharge at the commencement of this stage. C_2 now starts to charge and V_{g3} falls gradually to zero. V_a falls as C_1 discharges and the cycle repeats.

By an adjustment of R_1 and R_3 the charging time, and hence the duration of the sawtooth, is made controllable. R_2 controls the mark/space ratio of the square waveform at the screen. The oscillations can be synchronized if negative pulses are applied to the control grid, or alternatively if positive pulses are applied to the suppressor grid. The cumulative action occurring at the end of Stage B is initiated by either of these methods of synchronization.

Finally, whether the cumulative action can occur or not depends very much on the relative grid potentials, and, in particular, that of the anode should be fairly low.

TUNNEL DIODES

By "CATHODE RAY"

NEGATIVE RESISTANCE WITH TWO ELECTRODES

HERE is another request programme. And it made me yearn for the good old days when the task of producing a convincing explanation of how an electronic device worked could be undertaken without risk of mental collapse, either for oneself or one's readers. What made me particularly nostalgic in this case was that the characteristic curve of a tunnel diode (Fig. 1) is practically a repeat of that of the old screen-grid tetrode or dynatron. Would that its cause were as easy to understand!

To build up our self-confidence by continuing to see daylight for at least another paragraph or two, let us consider the effect before the cause.

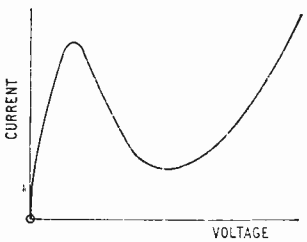

Fig. 1. General shape of tunnel diode current/voltage curve. It reminds those who are old enough to remember such things of the dynatron.

The characteristic curve of ordinary resistance, as known to Prof. Ohm, is, of course, a straight line passing through the origin and sloping upwards from left to right. The amount of resistance represented is inversely proportional to the steepness of slope. Two parts of the curve in Fig. 1 at least slope upwards from left to right. One of them even passes through the origin, and the other looks as if it could do if it continued its trend. But between them is a section sloping downward from left to right. An increase in voltage causes a decrease in current. The resistance within the limits of this section is, therefore, negative. Unlike positive resistance, practical negative resistance can't extend indefinitely. In this case, it changes over to positive resistance at each end of its limited range by passing through infinitely high resistance. There are other devices in which the resistance passes through zero, as in Fig. 2. This is sometimes called an S curve, to distinguish it from the N curve of Fig. 1.

There are more important distinctions between these two kinds of negative resistance, which we looked into at some length in the January and February, 1957, issues. The most practically important is that whereas the S or current-controlled type is most likely to make a circuit oscillate if its resistance is low, the N or voltage-controlled type does so if its resistance is high. This is shown in Fig. 3, where two load lines are drawn, APB representing a lower positive resistance than the negative resistance, and CPE a higher resistance. And if you are unaccustomed to load lines and think I must be getting muddled in saying these represent positive resistances, I must explain that their scale of voltage runs to the left from A and C, not to the right from O, so the sign is reversed.

If the total voltage OA is applied to the low positive and the negative resistance devices in series, the one point P common to both their graphs means that the voltage OA divides between them in the proportions OF and AF, and the current through both is represented by OG.

On the other hand, if voltage OC is applied to the high positive and the negative resistance devices, there are three possible states, represented by D, P and E. And, whereas E and D are stable, P is unstable, which means that if the line EPDC represents the dynamic resistance of a tuned circuit at

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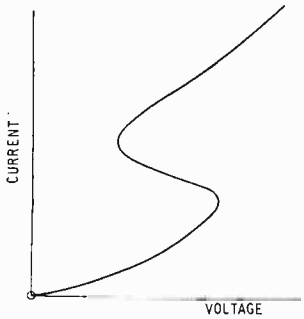

Fig. 2. This is an alternative type of negative - resistance curve.

some frequency it will be made to oscillate at that frequency, while if it is an ordinary d.c. resistance the current and voltage will flip over to either E or D.

The uninitiated may be surprised at this, arguing that since EPDC represents a larger positive number of ohms than the negative number of ohms in series, the total resistance must be positive. As I hope those who were with us in 1957 saw, however, the N type of negative resistance works in such a way that the rest of the circuit is effectively in parallel; and if you calculate the combined resistance of, say, -400Ω and $+500\Omega$ in parallel you will find that the answer is $-2{,}000\Omega$.

If the figures were reversed, so that -500Ω was combined with $+400\Omega$, the result would be $+2{,}000\Omega$; which means that the circuit would be stable but with a greatly increased positive resistance. If the 400Ω was a dynamic resistance, the effect of the negative-resistance device would be to raise it five-fold, increasing its Q, selectivity and sensitivity.

So a negative-resistance device can be gainfully employed either to improve the performance of tuning circuits or to stimulate oscillations therein, as desired. In untuned circuits it can be used as a high-speed switching device. For instance, if the working point were initially E, a positive voltage pulse CC′, sufficient to lift it over the hump, would make it flip across to H, and thence to D at the end of the pulse. The status quo could similarly be restored by a negative pulse.

The most familiar negative-resistance devices work by means of positive feedback, which requires a minimum of three electrodes to operate it. And so

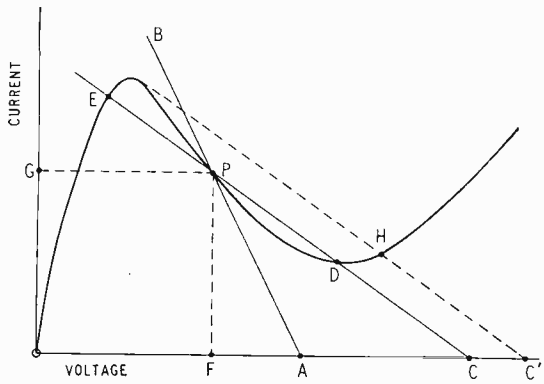

Fig. 3. Load lines applied to Fig. 1 show that interesting results are obtained when the load resistance is greater than the negative resistance; for example, EPDC.

we need valves and transistors. The snag about them is that they—especially transistors—get into difficulties at very high frequencies because of the time taken for electrons or holes to cross from one electrode to another; the "transit-time effect." There are also complications due to capacitances between the various electrodes.

Esaki's Diode

These difficulties are not necessarily avoided in two-electrode devices—diodes. Some, such as the ordinary metal rectifiers for 50 c/s, have so much interelectrode capacitance as to be unsuitable for high audio frequencies, let alone very high radio frequencies. Although point-contact germanium and silicon diodes—and junction types, if small enough—have reasonably little capacitance even by v.h.f. standards, their transit time may not always be negligible. And in any case, diodes don't normally show any kind of negative resistance. Fig. 4 is a typical characteristic curve, with the usual familiar features: hardly any current due to reverse voltage,

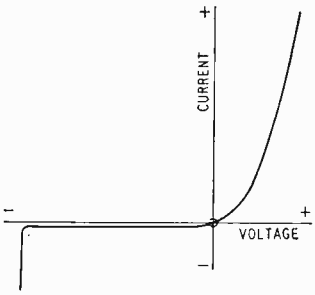

Fig. 4. Typical characteristic curve of conventional rectifier diode.

until the breakdown point, and rapid increase of current with comparatively small forward voltage, of the order of tenths of a volt.

Such characteristics are just what one wants in a rectifier, and are obtained by a junction between semi-conductors of the same material distinguished from one another by only perhaps one or two parts of opposite kinds of impurity in every thousand million. One can vary the breakdown voltage and the top working frequency to suit requirements by varying the proportions of impurity. The more the material is "doped" with impurity, the lower the breakdown voltage; and although this tendency may be acceptable, within reason, for the sake of a higher working frequency, there is a limit. If it is carried too far, the breakdown voltage becomes so low as to be practically non-existent; in which case the thing ceases to be a rectifier at all. Most people wouldn't pursue the matter any further, but there is sometimes something to be said for the generally anti-social occupation of carrying things too far. Considerable fame has come to a Japanese experimenter, Dr. Leo Esaki, for doing just that. He tried something like a million times as much impurity as in ordinary rectifiers—10^{29} atoms of it per cubic centimetre, or one part in a few hundred—and at the same time reduced what is called the depletion layer between the two sides of the junction to one millionth of a centimetre, or about a fiftieth of a wavelength of light. As we shall see, the extreme thinness of layer tends to result automatically from the extremely heavy doping.

Although a diode constructed on these lines offers

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hardly any reverse resistance, the forward curve above about one-third of a volt is hardly affected. The important thing, however, is what happens within that first third of a volt. It is shown in Fig. 5, with the characteristic of a typical rectifying diode dotted in for comparison.

This is the sort of thing that you and I could hardly have foreseen, and even when confronted with the experimental fact we would be hard put to it to think up a plausible explanation. I'm not at all sure that you will regard the official explanation, when we come to it, as plausible; if not, the onus will be on you to produce a better one. Meanwhile, shall we continue to put off the evil day by taking note of the practical side of this development.

We have become so accustomed to reading about fabulous new semiconductor devices proposed by exotic scientists, not obtainable in the foreseeable future, if at all, that it may be hard to take in as an actual fact that this most unlikely one can be obtained now by ordinary people, in at least six varieties with such commonplace type numbers as JK10A and JK11A, by sending a finite amount of cash to Standard Telephones & Cables, Ltd., Footscray, Kent. But so it is.

10,000 Mc/s

Laying a ruler parallel with the downward slope of Fig. 5 and reading off current and voltage, we find that the negative resistance is of the order of 40 ohms. This compares with 10kΩ for an exceptionally good dynatron valve. Remember, the lower the value of an N-type negative resistance the more potent it is, for it will produce oscillation in any circuit with a dynamic resistance numerically higher. Tunnel diodes with lower values than 40Ω are even easier to make. In fact, the lowness of their negative resistance tends to be embarrassing because of the difficulty in getting the power supply and connecting lead impedance low enough for the system to be stable at all frequencies, except perhaps one. On the other hand, there is no difficulty in getting

Fig. 5. Curves of tunnel diode and ordinary diode show some striking differences.

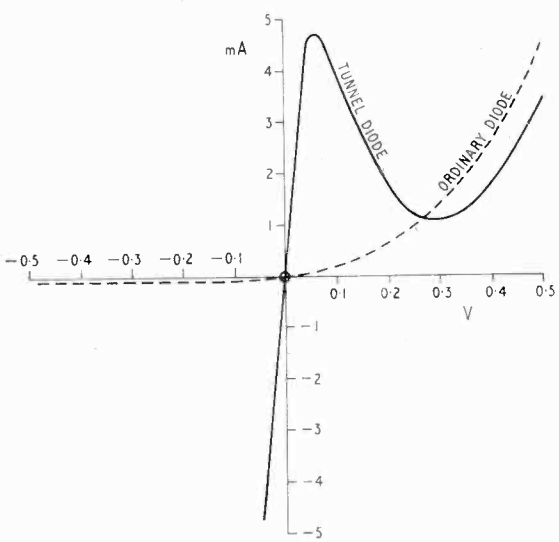

Fig. 6. (Below) Diagram of the ionized impurity atoms scattered about a piece of n-type semiconductor.

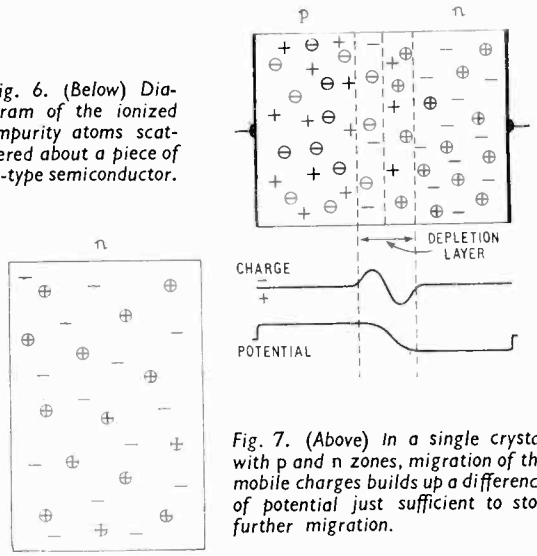

Fig. 7. (Above) In a single crystal with p and n zones, migration of the mobile charges builds up a difference of potential just sufficient to stop further migration.

the dynamic resistance of oscillatory circuits low enough, even at the highest frequencies. That, of course, would be no consolation if the diode ceased to function as per Fig. 5 at the said frequencies. But experimentally at least, tunnel-diode oscillation has been reported up to 5,300 Mc/s, and 10,000 Mc/s is confidently expected.

Before considering why this is possible, we will probably find it helpful to remind ourselves why a decade of struggle with transistors has failed to make them work at anywhere near such frequencies. One reason is that there is not merely one junction for the current carriers—electrons or holes—to cross, there is the whole base layer between two junctions. And except in the comparatively recent "drift" transistors, in which the base doping is tapered to produce an accelerating field for hurrying the carriers along, they just stroll across it in their own time.

In a *pnp* transistor, for example, the base—the meat in the sandwich—consists of *n*-type semiconductor. That is to say its material (usually germanium) is doped with an impurity whose atoms have one movable electron each. The main body of each atom, fixed permanently in the crystal structure, is therefore one electron short and so is electrically a positive charge. These fixed charges are denoted in Fig. 6 by plus signs in circles, and their mobile electrons by uncircled minus signs. The electrons are called majority current carriers because —well, they are in a majority, greatly outnumbering the few holes knocked out of the germanium atoms by heat, etc., or straying in from the neighbouring emitter. These emitter holes—the minority carriers —are responsible for the operation of the transistor, however, for they are the ones collected by the negatively biased collector. The base as a whole has hardly any electric field in it, because the equal and opposite charges distributed throughout it, as indicated in Fig. 6, cancel out.

In tunnel diodes, on the contrary, it is the majority carriers that count, and their journey is very short indeed. But we are still no nearer accounting for the essential feature of the tunnel diode: the low-

(*Continued on page* 411)

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voltage hump and negative-resistance slope in Fig. 5.

Again, let us remind ourselves how the conventional *pn* junction diode works. Fig. 7 is a diagram of one, the *n* half being originally the same as Fig. 6 and the *p* half the same in reverse. As we have seen, when separated they have no net electric charge. The mobile carriers in both halves are moving randomly all the time, and when both share the same crystalline structure there is nothing at first to stop the carriers nearest the boundary from straying across it. Electrons doing so leave behind an equal number of unneutralized fixed positive atoms on the *n* side, and incoming stray holes increase the positive charge there, as well as leaving behind a negative charge on the *p* side. The potential difference thus created checks further straying and a balance is quickly reached. This p.d., of the order of quarter of a volt in germanium, necessitates an external voltage of that order, positive to *p*, to overcome it and make current flow freely across the junction. Hence the rather slow start of the dotted curve to the right of zero in Fig. 5.

If the voltage applied externally to *p* is negative, it increases the existing p.d. between the two sides of the junction and stops all current flow (except the small leakage due to hole-electron pairs created among the germanium atoms, due to heat, etc.). Note that, provided the material changes abruptly from *p* to *n* at the junction, the more heavily the material is doped the greater the total charge created by a withdrawal of mobile carriers each side of the junction for a given distance, and therefore the less that distance for a given number of volts p.d. So one would expect a tunnel diode to have a phenomenally thin depletion layer.

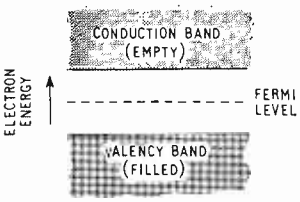

Fig. 8. Energy-level diagram for a perfectly pure semiconductor.

The Fig. 7 sort of picture tells only part of the story. It fails to take account of the fact that in solid materials the existence of current carriers and an e.m.f. isn't enough to guarantee a current. There must also be vacant energy levels right at hand for the current carriers to step into. (If that remark doesn't make sense to you, a little homework will be necessary before proceeding further. Most of the 1958 Cathode Ray instalments refer, especially the one in the July issue.) In a pure semiconductor the mobile electrons completely occupy a band of energy levels called the valency band, and the nearest available levels are in the so-called conduction band, separated by a gap, or band of forbidden levels, as in Fig. 8. As the vertical scale in such diagrams indicates the energy of electrons, upwards is negative. The Fermi level is a sort of reference, like sea level in geography. Below it, more than half the available energy levels are filled; above it fewer than half are filled. At absolute zero temperature, when all the electrons are at rest like a calm sea, it marks their "surface." At ordinary temperatures, heat disturbs the electrons, giving them enough energy to lift some to higher-than-Fermi levels; and as they leave behind an equal number of lower-than-Fermi holes the situation is vertically symmetrical, so the right place for the Fermi level is in the middle of the gap.

The promoted electrons have plenty of room to move about in the nearly empty conduction band, and likewise the holes in the valency band. What this amounts to in practice is that these "particles," very few in number, are available as current carriers; they are responsible for "intrinsic" or both-way leakage conduction, which is a nuisance in transistors and diodes, and as one might expect increases with temperature.

Impurities upset the balance by creating a very narrow empty band just above the valency band in *p* material, or a filled band just below the conduction band in *n* type. These gaps are so small that they are crossed freely by electrons at ordinary temperatures, leaving holes behind. The increased conduction so caused normally far outweighs the intrinsic conduction, which we shall now ignore. The new balance is indicated by the Fermi level rising towards the impurity gap in *n* material and falling towards it in *p* material.

While impurity greatly increases conduction throughout material of either kind, the state of affairs is more complicated in a crystal which is *p* at one end and *n* at the other. If no voltage is applied externally, the Fermi level is the same for both sides, as shown in Fig. 9. This creates the potential step we have seen already at the foot of Fig. 7, preventing current flow from one side to the other. Connecting a battery to the crystal diode alters the relative potentials of the *p* and *n* halves, shifting their Fermi levels and either reducing or increasing the step according to whether the battery is positive to *p* or to *n*.

The more impurity is included, the more it dominates the situation, until, with the altogether abnormal amount used by Esaki, the upper levels of the valency band are practically cleared and the lower conduction levels filled, so the Fermi level is actually inside the main bands, as in Fig. 10. So far from explaining the early rise of current in Fig. 5, this would seem (in the light of all we have remembered) to make it even more impossible, by increasing the height of the potential step.

Tunnelling

To rescue us from this difficulty we must look to one of the most apparently fanciful theories of modern science, which tells us that when things are as small as electrons it is impossible for them to be clearly defined particles. They behave as waves of probability. I tried to explain that not very easily intelligible concept in the November 1958 issue.

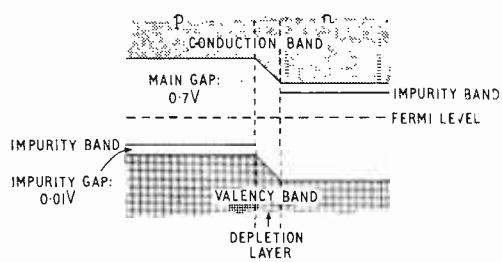

Fig. 9. Energy-level diagram for p-n junction with very small impurity content, as in a rectifier diode.

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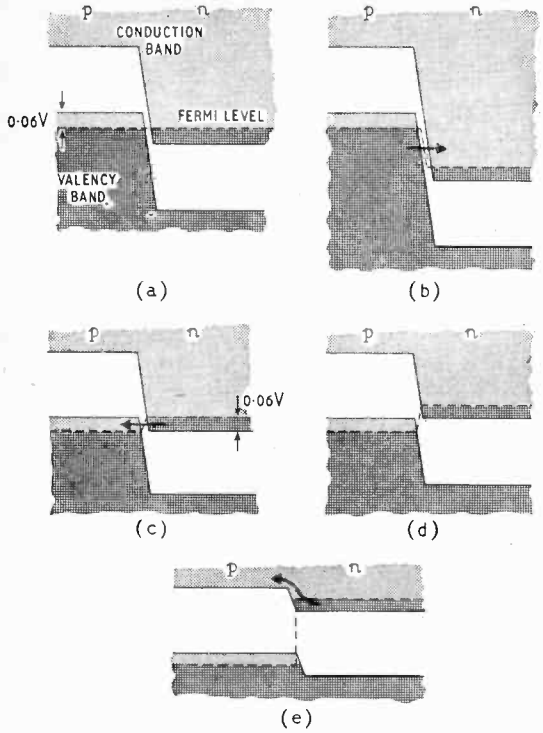


Fig. 10. Diagram corresponding to Fig. 9, for a high-impurity (tunnel) diode.

Discarding all set ideas about what extremely small particles are like, because we have no right to assume they are just like particles we can see only smaller, we must accept experimental evidence of their dual personality, wave-like as well as particle-like. Just as the band of waves that combine to form a square signal pulse can never have a perfectly defined start and finish, and the uncertainty is negligible with wide pulses but appreciable with very brief ones, so there is uncertainty about the position of a particle as small as an electron. It can be visualized as a sort of haze; the local density of the haze, which is greatest in the centre and gradually tails off as the distance therefrom increases, being a measure of the probability of finding the electron there at any given moment.

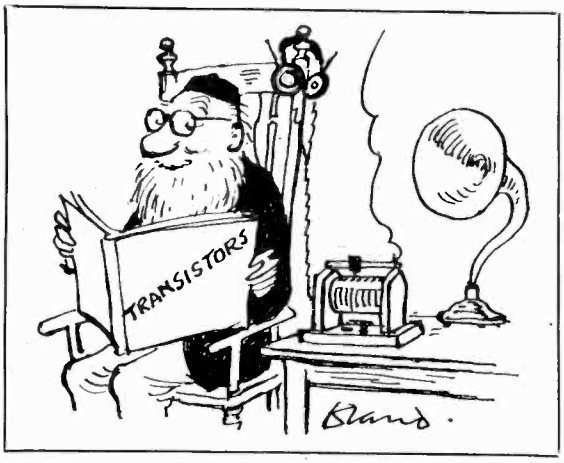
Now if an electron is close to a potential barrier as thin as in a tunnel diode, its haze extends beyond the barrier, and if there is a vacant place for it an appreciable possibility exists of its being there, even though it doesn't possess enough energy to climb over the barrier. With one electron, that is rather like the statistics which say that if you are alone in a room that room contains 0.01 (or whatever it is) tuberculous persons. Just as you get a more sensible result by applying such information to a crowd outside Buckingham Palace, so one reaches the conclusion that when there are trillions of electrons milling around close to a thin potential barrier an appreciable number are on the far side, and since they couldn't have climbed over it they are regarded as having tunnelled through it.

Taking another look at Fig. 10, we see that in diagram (a), which represents zero applied voltage, there are no filled levels alongside empty levels on either side, so there is zero current, even when tunnelling is allowed. But when the *p* side is made negative, by what is usually called back voltage, as indicated by the step in the Fermi level in (b), part of the valency band on the *p* side, bursting with electrons, is separated only by a fantastically thin depletion layer from empty levels on the *n* side. This means a fairly good conductivity across (or through) the barrier, the arrow showing direction of electron flow. This accounts for the steep downward slope to the left in Fig. 5, in contrast to the ordinary diode (Fig. 4).

A *small* forward voltage (c) permits current in the opposite direction. But as this forward voltage is increased, the number of empty levels opposite full ones decreases (d), so the current falls off, causing the negative-resistance slope. Finally, further increase of forward voltage (e) progressively reduces the potential barrier, causing a rising current as in an ordinary diode.

Besides the useful features we have already noted, tunnel diodes are less upset than transistors by radiation of various kinds. This may be important in nuclear equipment. They are more tolerant of temperature, working happily at hundreds of degrees below and above zero. They are likely to be much less affected by contamination, and the expensive precautions against it needed for transistors and rectifier diodes should be largely unnecessary. They are very small and simple. On the other side of the balance sheet: Being diodes, they are not even approximately one-way in action as are transistors. For their resistance to be high enough to match reasonable circuitry, their size is necessarily small and their power-handling correspondingly limited. Fig. 5 shows how limited is their working voltage range.

But these are early days, and there is already reason to believe that the conventional germanium and silicon may not display the full capabilities of tunnel diodes. Indium antimonide and gallium arsenide are being tipped as winners. Computers performing operations at 50 Mc/s, compared with 1 Mc/s which is regarded as quite good in present practice, are forecast. Uses in television receivers, especially frequency changing and amplification in bands IV and V, seem likely. All in all, then, I'm not disposed to lodge an objection against the claim that the tunnel diode is the most important semiconductor development since the junction transistor.



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IMPROVED PRINTED WIRING

NEW TECHNIQUE GIVES GREAT BOND-STRENGTH

MANY criticisms have been made of printed wiring in the few years it has been with us. Today many of the troubles discovered in its early use have been, if not overcome completely, reduced in their incidence; but the application of palliatives has not been easy. A new method for producing printed-wiring boards, developed by Electronic Circuits, Ltd., shows great promise in being free from the majority of nasty habits that have possessed most foil-laminate circuits in the past in varying degrees.

The wiring pattern is printed on the substrate with a bonding medium and finely divided copper is then applied, resulting in a granular-copper pattern. This is then deoxidized and very quickly tinned by a roller-coating process to give a solder-coated wiring board. Conductor resistance is equivalent to that achieved by the use of 1-oz copper foil (1.5×10^{-3}in thick).

This technique shows greatly improved bond-strength compared with the normal foil-laminate construction. The photograph shows a test-piece to which a strong wire was soldered, end on. It was possible to pull off by hand the wire, but only with considerable effort. The result in each case was a rupture of the board material: the wire came away with the printed wiring attached to it bearing on the back a considerable amount of synthetic-resin-bonded paper board material.

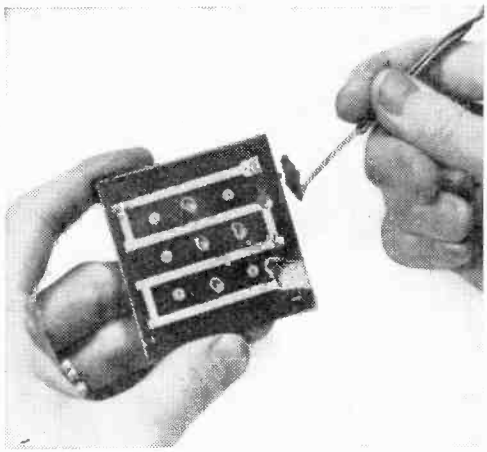
The normal peel test which demands an "end" of copper to peel cannot be applied; but performance should be eminently satisfactory, as in none of the pull tests did the wiring separate from the board material. No etching process is involved, as it is with the traditional construction, so that a section through the pattern shows, instead of undercut conductors, a meniscus form.

Switch and plug contacts can be plated on to the solder in the normal way, following milling down of the surface to provide a level base. Particularly successful are palladium or gold over hard nickel.

Ordinary flow solder and solder-dip techniques may be used for connecting component leads. Normally, with solder-tinned leads, no fluxing is required. The solder of the bath, leads and circuit dissolve into each other forming a good joint even in the presence of foreign matter. Advantages here, of course, are that the risks of corrosion from decomposed or damp flux deposits are completely eliminated, as are "dry" joints. It is possible, by repeated application of fresh copper-free solder, to dissolve away the copper particles on a very thin (too thin to be of use as part of the circuit) line; but provided normal soldering practice is followed this does not occur. The use of a copper-rich solder for servicing work naturally eliminates even this slight opportunity for failure.

Last, and in this case definitely least, is cost. It is expected that this process will allow the production of punched boards at about the same price as etched-foil boards unpunched. Further economies could be made in assembly-line working due to the rougher treatment and simpler processing possible so the final all-round result should be cheaper, more-easily made equipment of better reliability.

The address of Electronic Circuits Ltd. is 177 Kensington High Street, London, W.8.



Deep ruptures of the substrate material occur in ordinary pull test. Wiring pattern does not separate from board material.

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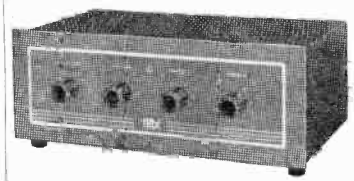

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RANDOM RADIATIONS

By "DIALLIST"

The Report

THE Television Advisory Committee's report is clearly the result of much hard work and of much hard thinking. With many of its recommendations most people agree. What I do regret is that a 625-line standard should have been recommended. The Committee feels that this is the last opportunity we shall have for 25 years of improving the definition of our television and I really can't feel that the 625-line standard will be accepted as adequate for anything like such a time. Nor do I find it all that much better than 405 lines. Readers who have been for holidays or on business to countries using 625 lines will, I fancy, hold similar views. It is better, but not strikingly better. I should have liked to see a much bolder proposal: to use Bands IV and V for something like 1000-line television. If you've been to France and seen the R.T.F.'s 819-line pictures on a good set, you must have been struck by their enormous superiority to ours.

Other Considerations

There are, I know, several reasons against the adoption of a really high standard. Not the least of them is that nine viewers out of ten don't seem to care two hoots about the quality of the pictures on their screens. No doubt you've found, as I have, that non-technical friends aren't in the least worried about all sorts of shortcomings that would drive you and me crazy, and they make no attempt to have them put right. Faults, I mean, such as poor focus, incorrect height or width, "soot-and-whitewash," ringing, poor h.f. response—and dozens of others. Against that, the desire for a big screen is very strong and with the present standard you can't profitably have a very large screen in the smallish rooms of modern homes unless you're prepared to put up with lininess. Another suggestion of the Committee's is that the adoption of their proposals would enable us to have eventually no fewer than five TV networks. Five!—but where's the material coming from? The supply of actors, singers, comedians, instrumentalists, variety artists . . . and so on and so forth for even two networks doesn't appear to be superabundant nowadays. Wouldn't it just mean more and more films? Surely, television should stick as much as possible to actualities—the presentation of things as they happen; and TV films should be mainly recordings of them.

More DX Feats

LONG-DISTANCE reception of both v.h.f./f.m. and television signals seems to be gaining increasing popularity. A reader writing from Twyford, in Buckinghamshire, tells me he has had a receiver specially modified to 625 lines and with this he has been remarkably successful. This set is a standard domestic model, not even a fringe-area type. He uses normally a Channel 1 vertical "H" aerial, but he has also a Channels 4-8 combined aerial, also vertical. So far this year, he writes, he has had direct TV pictures from Italy, Czechoslovakia, Spain, Hungary, Russia, Italy, Germany, Rumania, Sweden and the Netherlands. He sends some remarkably good photographs of pictures from some of these countries received on his screen. A reader who lives at Antwerp (though he's not a Belgian) tells me that he has at any time a choice of seven or eight stations in Holland, Belgium, France and West Germany, all of which provide first-rate reception. He is the fortunate owner of an aerial rotatable in azimuth and provided with a motor to turn it in the right direction

819 Lines Too

Though I'd heard that the French 819-line transmissions could produce a locked picture on a 405-line receiver, I'd never, until recently, had any definite evidence on the subject. Now it has come along in the form of clear photographs of his screen from a reader living at Shenfield, Essex, who uses a standard domestic set. What does come as a biggish surprise is that his successes have been achieved with a 5-element Band III aerial, mounted at first in the loft of his bungalow and now fixed to a 14-foot pole outside. He tells me that on an average of five evenings a week he can obtain a picture. On the best evenings it is not much inferior to those of the B.B.C. and I.T.A., which should be first rate at Shenfield; on other evenings it is just usable. Perfection couldn't be expected, naturally, for our standard receivers aren't designed to cope with such large modulation bandwidths as are used in French television. I'd be glad to hear of any other instances of successful 819-line reception on standard 405-line receivers.

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Prehistoric Electric Cell?

THE June issue of the *Journal* of the I.E.E. contained a note by C. MacK. Jarvis concerning an article recently published in the German journal *Elektric* on an object discovered near Baghdad about 1936. Archaeologists put the date of other objects excavated on the site as between 300 B.C. and A.D. 300. It is a kind of vase, about 6-in high, made of yellow clay. Inside it is a copper cylinder held in place by the asphalt lining of the vase and containing an iron rod kept in position by asphalt discs at top and bottom. It is suggested in the German journal that this was an early form of electric cell and that galvanic gold plating had been carried out with the aid of similar cells from as early as 2500 B.C. A fascinating idea, but there doesn't seem to be much to support it. One can hardly believe that the galvanic cell, if developed by the Parthians and used over a long period, would simply have disappeared until Galvani "rediscovered" it. And C. MacK. Jarvis suggests something that seems fatal to the idea of the practice of gold plating by electricity in those days; no solvent of gold was known to the ancients and there were, therefore, no gold salts.

The Moon's Surface

INVESTIGATIONS into the nature of the moon's surface were recently undertaken by V. A. Hughes of the Royal Radar Establishment at Malvern. He used a 2MW radar transmitter, the wavelength being 10cm, in conjunction with the Malvern 45ft radio telescope. In a letter in *Nature* of June 11th he states that the surface appears to have numerous small ups and downs. The height or depth of these is not great, being mainly a matter of a few feet; but their width may be 20 times greater. I wonder if further investigations will confirm these conclusions? They don't agree very well with the results of optical methods, which give ground for believing that the moon's surface is covered mainly by fine volcanic dust. I suppose that hillocks and depressions could occur in this, though there can't be any wind to make them.

Servicing Exams

LAST month I incorrectly referred to the "R.T.R.A. exams. and certificates." The servicing examinations in question are, of course, run jointly by the Radio Trades Examination Board and the City and Guilds of London Institute.

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From the Horse's Mouth

JUST lately we have heard a lot about miniature secret transmitters concealed in the furnishings of conference rooms used by high diplomatic dignitaries. Even the gifts to our own Home Secretary on a recent tour were subjected, we are told, to strict screening by secret-service agents to see if they contained any hidden devices of this nature.

The menace of having our private conversations broadcast in this manner is a very real one, but I think secret-service Sherlocks are—if I may mix my metaphors—barking up the wrong tree when they examined things like Mr. Butler's "Presents from Margate." I cannot think the agents of any foreign power would be so crude as to place secret transmitters there when much more intimate places are available.

I was thinking of this as I was examining the "radio pill" on a stand at the Instruments, Electronics and Automation Exhibition held at Olympia in May. This pill, as many of you will know, consists of a small capsule which is swallowed by the patient. It houses a tiny radio transmitter which radiates information about the pressure, temperature and acidity of the patient's alimentary tract through which it passes.

It should be possible to fit it with a miniature mike so that it radiated the patient's conversation as it journeyed through his innards. But the danger of its use for espionage is negligible, as no statesman would go to a conference with one of these inside him, and in any case it only remains in the patient's body for a limited time.

As a precaution, however, it would probably be advisable for the breakfasts of all statesmen to be vetted on the morning of a conference, as it would be possible, I suppose, for an unscrupulous chef to conceal a capsule in the porridge.

In my opinion, however, it is not in the alimentary tract but in quite a different part of a statesman's body that a search should be made for a concealed transmitter. It must be clear to any thinking person that if a transmitter can be concealed in such a small space as the capsule exhibited at Olympia, it would be a simple matter for a dentist in the pay of a foreign power to conceal one in a cabinet minister's denture.

Enemy agents listening on their nearby receiver would thus have secret information straight from the horse's mouth, as the saying goes. It seems to me the remedy would be for a secret-service agent or a police officer to stand at the door of the cabinet room with a tray and collect all dentures as ministers passed inside, or, less comfortably, to hold the meeting inside one of those screened rooms one sees in microwave research laboratories.

Homo Infrasapiens

I MUST thank the many readers who wrote in answer to my query (June issue) to tell me that the circle is divided into 360 degrees because the astronomers of old—some say the Babylonians—were a bit out in their calculations and thought the year contained this number of days instead of 365 and a bit.

This is, I feel sure, the correct *conventional* explanation because all the books of reference are more or less in agreement about it. But the fact that this explanation seems to be accepted by all the best people does not necessarily mean that it is correct. After all, in every biography of King Edward VII we are told that he had his appendix removed when undergoing an operation in 1902. The only man to disagree is the late Sir Frederick Treves who was the presiding surgeon on that occasion. But he was in a minority of one like myself in this Babylonian affair.

My idea is that at some time in the life of the solar system the speed of the earth's journey around the sun may have been such that there were indeed just 360 days in the year. Needless to say, this was long before the coming of homo sapiens who has only been on the earth some 500,000 years and in that relatively short period of time, the earth's speed cannot have changed much, if at all.

If, however, we go back a sufficient number of million millenia, there may have been exactly 360 days in the year. I cannot say exactly when that was as I haven't an electronic computer handy to feed in the necessary data.

In my opinion, it may well be that in those distant days, the earth was inhabited by a race of pre-men (homo infrasapiens) much more advanced than ourselves in scientific knowledge but less well developed in the matter of morals, intelligence and political wisdom—hence the name infrasapiens—who wiped each other out in a nuclear war. According to my theory fragments of their ancient records which escaped destruction were found by the Babylonians who failed to realize that days and years had lengthened and therefore 360 was no longer the correct figure.

In the same way, fragments of our own records may be discovered a few million millenias hence when the solar system may have slowed down still more, and the people of those far-ahead days (homo supersapiens) will wonder what it was like to have had a year of such a few number of days as $365\frac{1}{4}$, and a day of such brief duration as 24 hours. They may even wonder what we meant by the word "war."

Why?

I AM always thirsting for information, and I wonder if any of you can tell me why an angstrom unit is so called? Now before you all take up your pens or typewriters to tell me all about Ångström and his work, I should like to say I am not ignorant of all that. What I want to know is why the seemingly unnecessary word "unit" is tacked on to angstrom. After all, we don't speak of an ampere unit nor yet an ohm unit, do we?

I wonder if it is due to sheer ignorance, of the type shown by certain people who tack the superfluous word wine on to Port when they wish to speak of the drink which comes from the valley of the Douro, but omit it when speaking of the bubbling beverage of the Champagne country, and of other forms of nectar.

Very false teeth.

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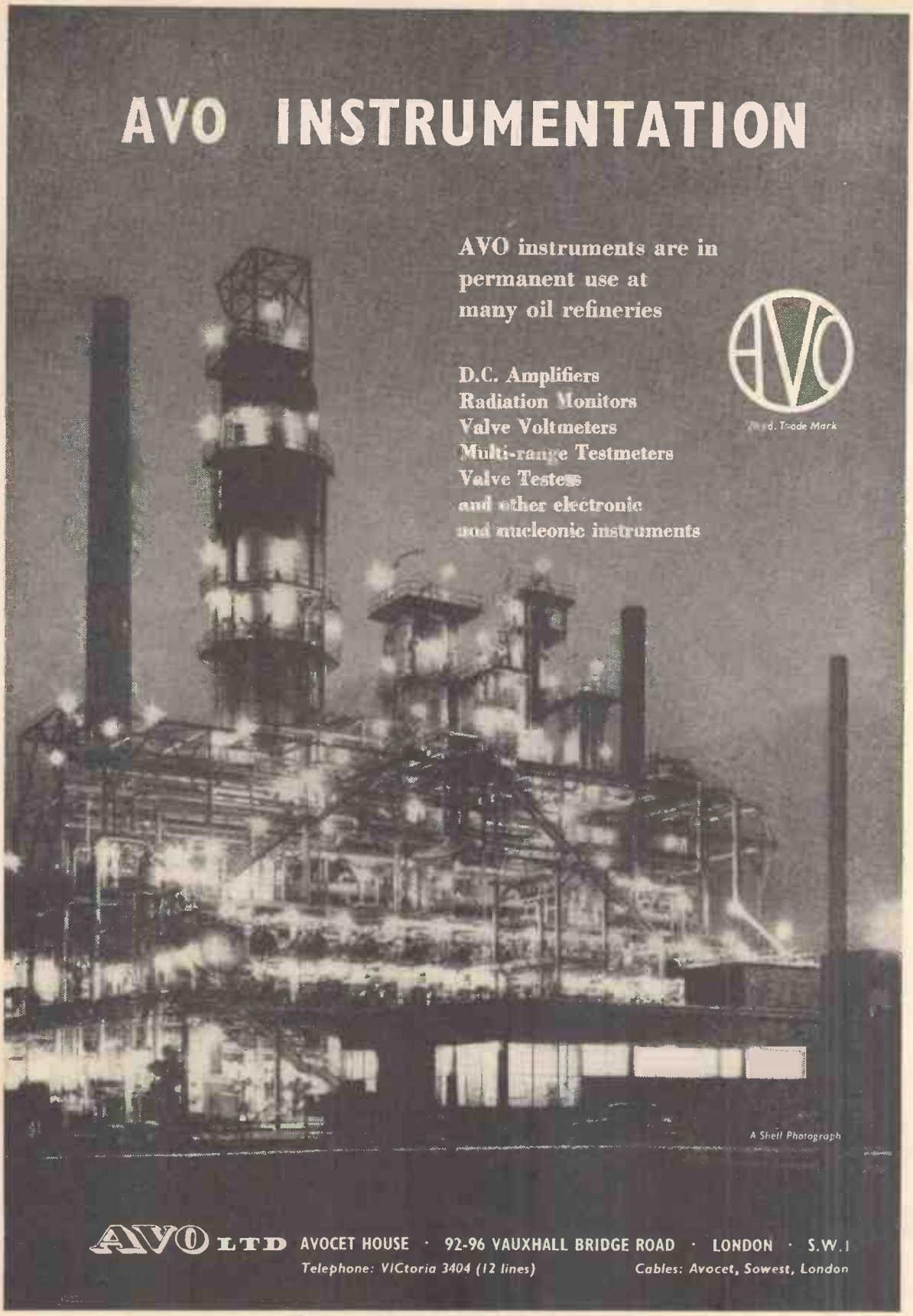

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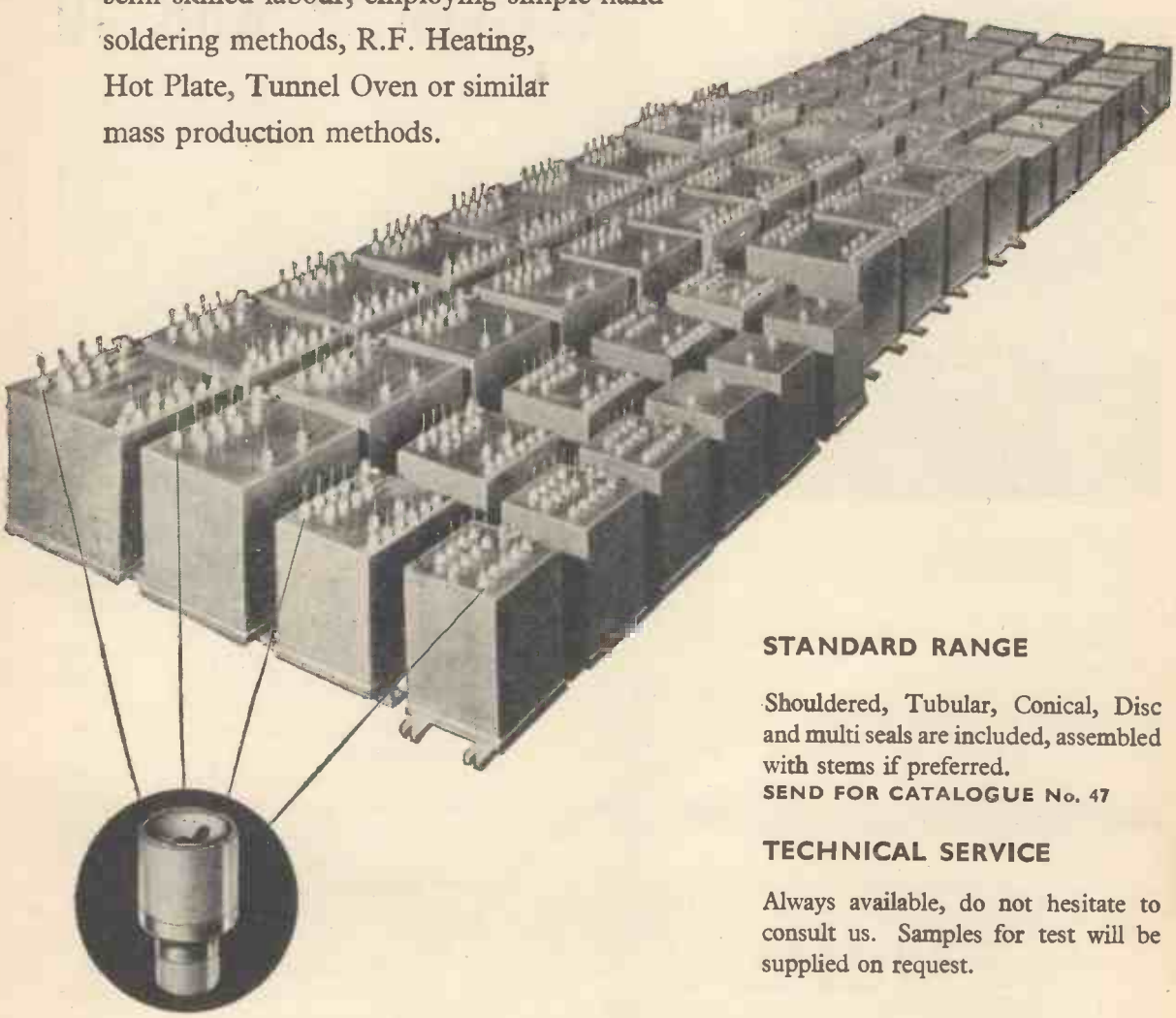

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Shouldered, Tubular, Conical, Disc and multi seals are included, assembled with stems if preferred.

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TECHNICAL SERVICE

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SP100

DELAYED PULSE AND SWEEP GENERATOR

A versatile pulse generator designed to meet the need for a comprehensive instrument covering a wide range of pulse work. Four main facilities are provided: a pre-pulse, a main pulse delayed on the pre-pulse, a negative going sawtooth and a fast rising pulse formed from a pure line.

BRIEF SPECIFICATION

Period

Continuously variable from 0·9μsec to 1·05sec i.e. 0·95c/s to 1·1Mc/s. Accuracy ±5%.

Pre-pulse

40mμsec. 8V peak in 75Ω, positive going.

Main pulse

Width: Variable from 0·09μsec to 105msec ±5%.

Amplitude: Control gives 4:1 attenuation of each of four maximum outputs as follows:

5V max in	75Ω	rise time	10mμsec
10V max in	150Ω	rise time	<20mμsec
25V max in	600Ω	rise time	<40mμsec
50V max in	1000Ω	rise time	50mμsec

Polarity: Positive or negative going.

Accuracy: ±2%.

Delay

Conclusion of pre-pulse to advent of main pulse, delay variable from 0·09μsec to 105msec. Accuracy ±5%.

Sweep

D.C. coupled negative going sawtooth same width and delay as main pulse. 15V peak max.

Cable pulse

Obtained from short circuited pure line. One positive and one negative going pulse coincident with main pulse. 25mμsec wide 3V max in 75Ω, rise time <8mμsec.

Sync, trigger or single shot facilities provided. Full data available on request.

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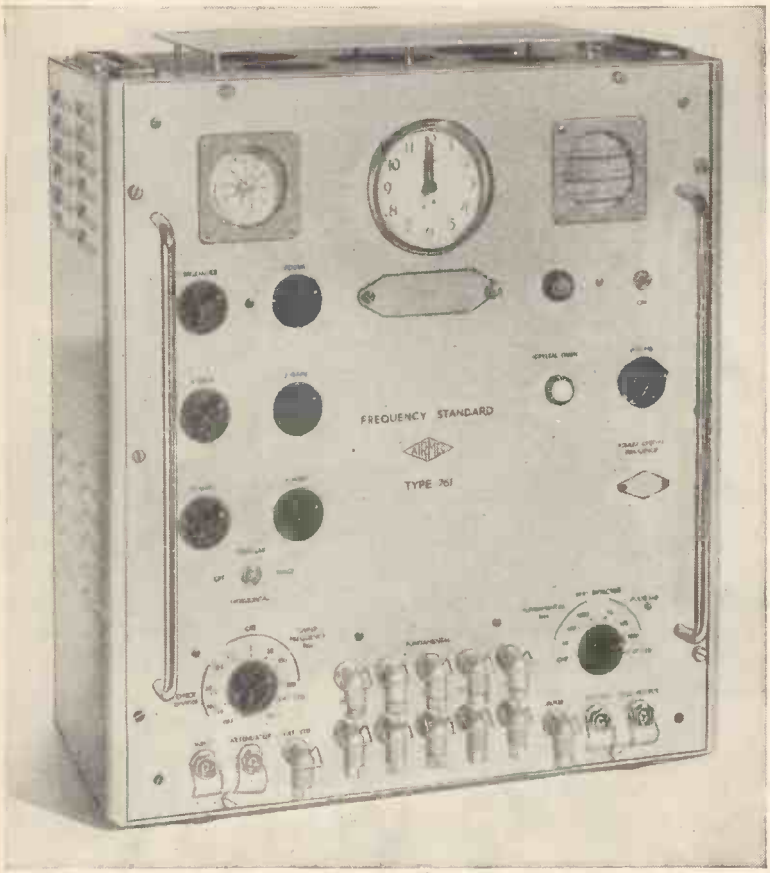

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TYPE 761

FUNCTION

Provides an excellent crystal controlled frequency and time standard of small size and moderate cost. The short term frequency stability of better than 1 part in 10^6 obtainable upon installation improves with time and correct treatment up to a working stability approaching 1 part in 10^7.

OPERATION

Sinusoidal and pulse signals are produced at five standard frequencies, the pulse waveform being rich in harmonics. The instrument includes both an Oscilloscope and Heterodyning Circuit as independent facilities and is therefore extremely flexible in operation.

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- **100 kc/s crystal housed in an oven controlled at 70°C.**
- **Standard signals provided at 100 c/s, 1 kc/s, 10 kc/s, 100 kc/s, and 1 Mc/s.**
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- **Beat output available from a plug on the front panel.**
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Specially designed to meet the varying needs of different homes. Mk. I houses Record Player, F.M. Tuner, Stereo Amplifier, records, etc. Mk. II will house a Tape Deck in addition. 46½in. long, 30in. high, 21in. deep. "In the white" for finish to personal taste.

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"COTSWOLD" HI-FI SPEAKER SYSTEM KIT
Acoustically designed enclosure "in the white" 26in. x 23in. x 15½in. housing a 12in. bass speaker with 2in. speech coil, elliptical middle speaker together with pressure unit to cover the full frequency range of 30-20,000 c/s. Complete with speakers, cross-over unit, lever control, etc. **£19.18.6**

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S-3U

F.M. TUNER

DX-100U

S-33

USP-1

S-88

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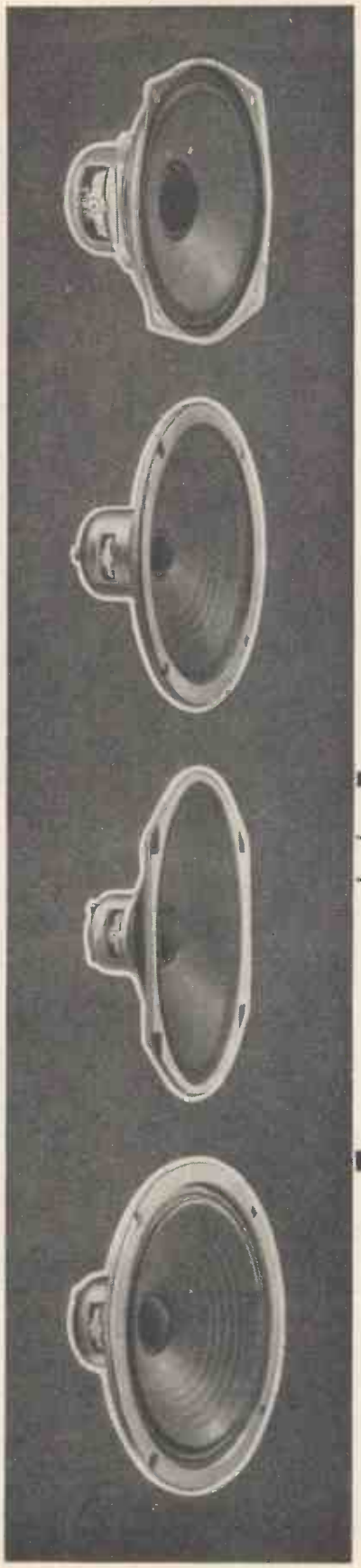

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We have made this selection from our wide range of speakers as they cover practically all the requirements of the replacement trade.

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6½in.	6G	6500 g	21/6	6/11
7 x 4in.	47G	6500 g	20/6	6/7
7 x 3in.	37G	6500 g	20/6	6/7
8 x 3in.	38G	6500 g	20/6	6/7
8 x 5in.	58C	8500 g	24/6	7/10
8in.	8C	7000 g	25/6	8/2

All loudspeakers have Standard 3 Ohm impedance. Higher impedances can be supplied at an extra cost of 3/- plus 1/- Purchase Tax.

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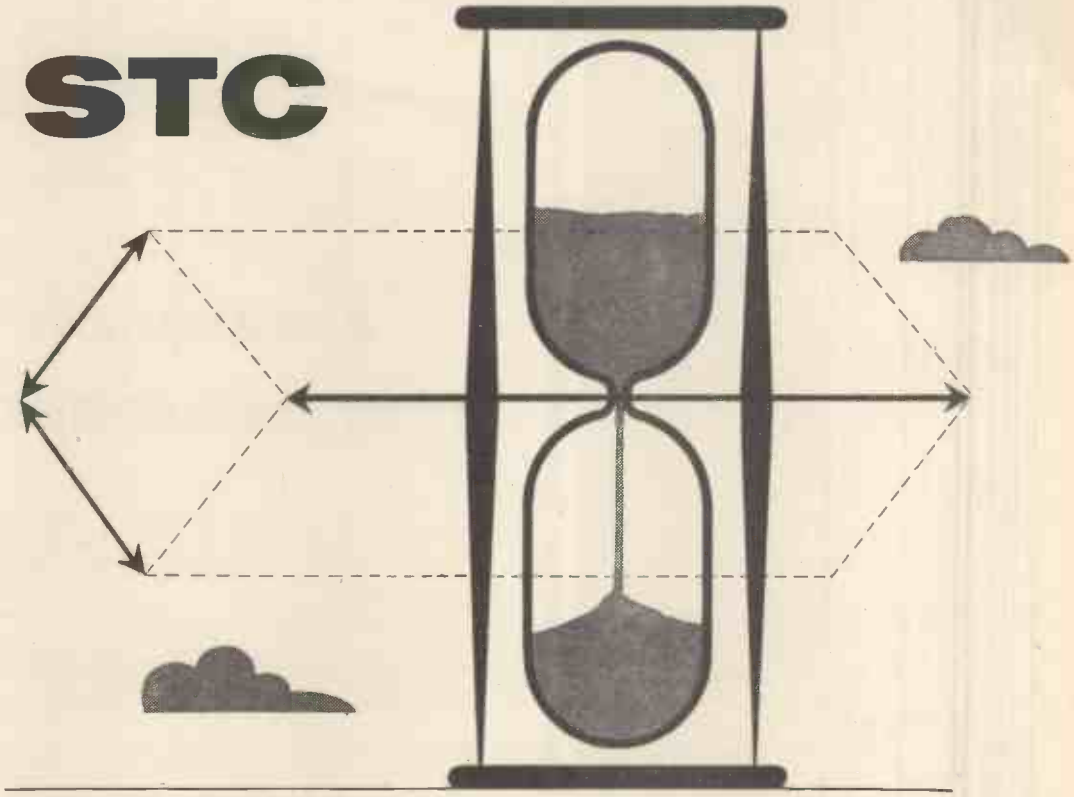

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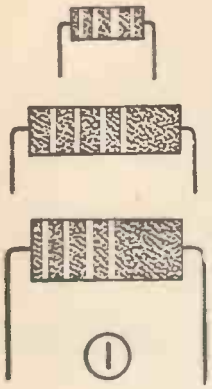

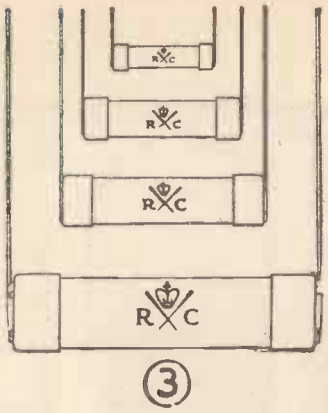

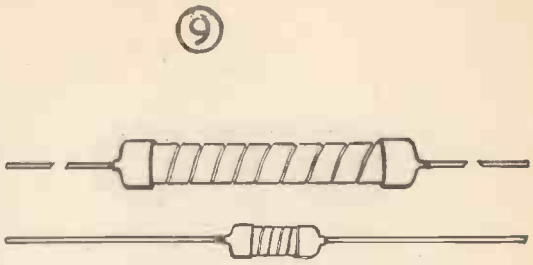

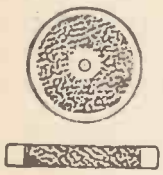

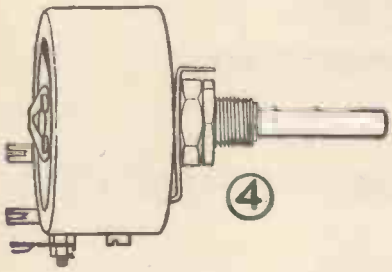

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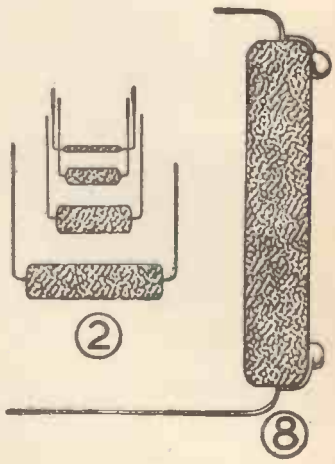

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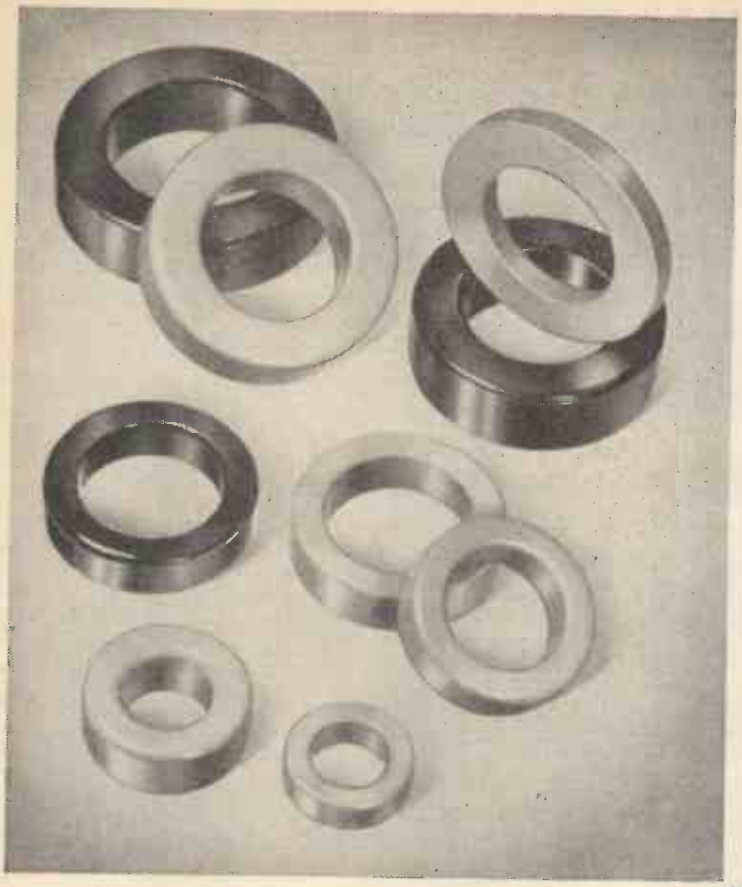

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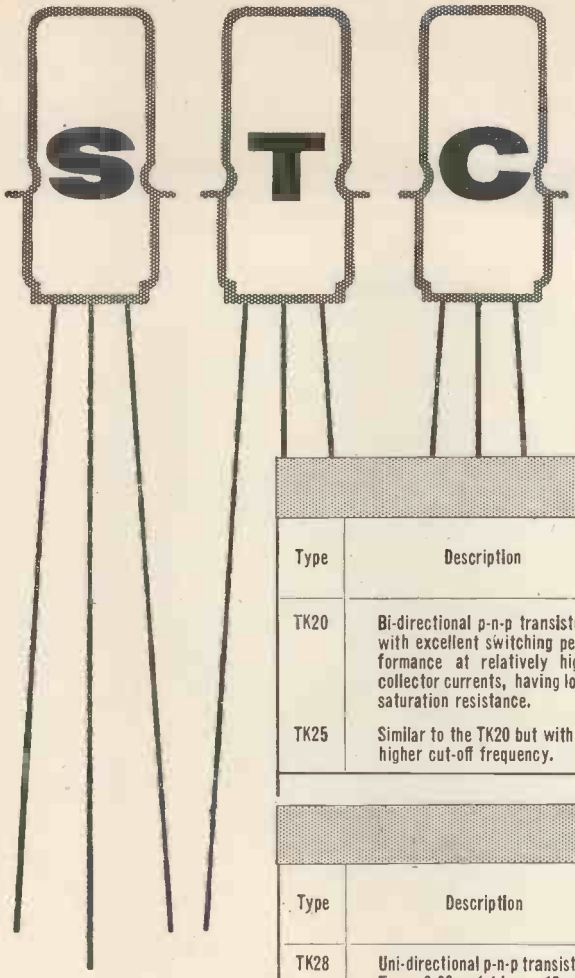


switching transistors for computers

TWO WAY

Type	Description	h_{FE} Min.	h_{FE} Typ.	h_{FE} Max.	measured at V_C (V)	measured at I_C (mA)	f_α Typ. Mc/s	V_{CB} Max. (V)	V_{CE} Max. (V)	$T_{junc.}$ Max. (°C)	P_C max. at 25°C (mW)
TK20	Bi-directional p-n-p transistor with excellent switching performance at relatively high collector currents, having low saturation resistance.	15 ¶15	35 35	95 95	-0.15 -0.15	-100 -100	6.0	-30	-12	75	0
TK25	Similar to the TK20 but with a higher cut-off frequency.	30 ¶30	50 50	125 125	-0.15 -0.15	-100 -100	11	-20	-6	75	200

ONE WAY

Type	Description	β Min.	β Typ.	β Max.	measured at V_C (V)	measured at I_C (mA)	f_α Typ. Mc/s	V_{CB} Max. (V)	V_{CE} Max. (V)	$T_{junc.}$ Max. (°C)	P_C max. at 25°C (mW)
TK28	Uni-directional p-n-p transistor $T_C = 0{\cdot}03\mu s$ (at $I_C = -15$ mA) $T_S = 1{\cdot}5\mu s$	†25	†46	—	-0.1	-3.0	—	-26*	*-25	75	200
TK30	A transistor with excellent switching performance and very low saturation resistance	20	40	85	-4.5	-1.0	6.0	-30	-10	75	200
TK31	Similar to the TK30 but with a higher cut-off frequency	20	60	150	-4·5	-1.0	11	-20	-6	75	200

† h_{FE} quoted instead of β ¶ Inverse * Reverse bias emitter junction

SUMMARY OF OTHER STC INDUSTRIAL TRANSISTORS

Germanium transistor for general purpose LF telephone and telegraph carrier systems	TK23		
For amplifiers and oscillators (audio and higher frequencies)	TK40	TK41	TK42
Silicon alloy junction transistors for amplifying, switching and control in extremes of ambient temperature	TK70	TK71	TK72

Data sheets and further information gladly sent on request.

STC COMPONENTS GROUP

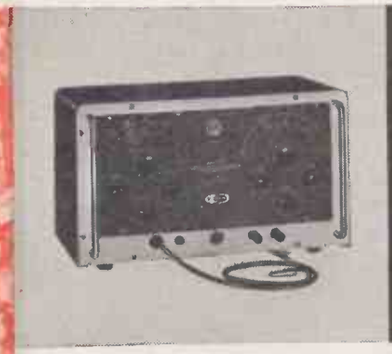
60/2MK

Standard Telephones and Cables Limited

Registered Office: Connaught House, 63 Aldwych, London, W.C.2.

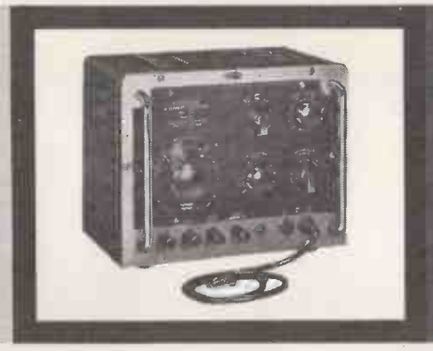
TRANSISTOR DIVISION: FOOTSCRAY · SIDCUP · KENT

SIGNAL GENERATORS



MODEL 1322

Sweep generator with internal crystal marker oscillator for all TV alignment procedure using standard oscilloscopes



MODEL 1324

Sweep generator for FM receiver alignment
Carrier 87.5 to 107.5Mc/s
I.F. channel 7.5 to 27.5Mc/s

MODEL 1046

A one millimicrosecond pulse source for testing wide-band amplifiers, delay cables and high-speed counters in nuclear physics
Up to 100V into 52Ω at 120 p.p.s.

MODEL 1090

A 3 to 4 millimicrosecond rise-time square-wave generator giving 0.5V into 70Ω at frequencies between 0.30-1.25Mc/s

MODEL 1450

Doubly-screened general-purpose signal generator for everyday laboratory use
frequency range: 150 kc/s to 390 Mc/s
accuracy: ±1% up to 33 Mc/s
±2% higher frequencies
Internal and external modulation

LCR BRIDGE

MODEL 1446

LCR Bridge with miniature CRT indicator
10 μH to 10H
10 pF to 100μF
1Ω to 10MΩ
accuracy ±1% ±1/minor scale division

AMPLIFIERS

MODEL 1449

For providing matched DC amplifiers for each trace of oscilloscope 1049 or an X amplifier identical in every respect to that of A1 for X-Y presentation

MODEL 1439

Wide-band amplification for simultaneous distribution of all signals in bands I, II and III enabling common aerial for a number of TV and VHF receivers
Gain 20dB 40-220Mc/s

MODEL 1440

DC pre-amplifier primarily designed for 1049 oscilloscope to give sensitivities up to 0.65mV/cm DC-25kc/s, 0.22mV/cm 5c/s-25kc/s (Used with model 1327 battery eliminator)

TRANSISTOR TESTER

MODEL 1325

Transistor tester. For easy, quick and accurate measurement of the parameters of all crystal devices, including high-gain and power transistors

FACT 1 ONE

a fast-growing multi-purpose Cossor range - with the built-in technological supremacy that has made Cossor oscilloscopes the best in Britain.

* Cossor made the first British Oscilloscope.
* Cossor provided Industry and Research with over 3,000 new Oscilloscopes last year.
* Cossor make more Oscilloscopes than any other Company in Europe or the British Commonwealth.

TRANSISTORISED POWER UNITS

MODEL 1326

A 6V-2A transistor power unit average ripple 300μV. output impedance <10mΩ stabilization 200:1

MODEL 1327

Battery eliminator primarily to power Cossor pre-amplifier 1440. Also suitable for circuits requiring high-voltage stabilization and low ripple content and output impedance
supply: L.T. 6-6.5V 1.7 A
H.T. 120V 15mA

MODEL 1328

Laboratory power source for transistor equipment; stability: 500:1; output impedance <10mΩ and ripple <1mV make it ideal in design of transistors and associated circuits Output continuously variable 0-30V at 1A. Two 3½in.

MODEL 1070

Positive and negative valve curve tracer. Using pulse technique to give information hitherto unobtainable on dynamic valve

SIGNAL DELAY UNIT

MODEL 1447

For delaying the work voltage to standard oscilloscopes until time-base has fired
DC to 11Mc/s—0.5μsec delay
DC to 8 Mc/s—1μsec delay

MODEL 1442

Laboratory high-gain amplifier for use in industry, nuclear physics, neuro and myo-graphic investigations
response: 5c/s to 3kc/s
gain: 10^6

VALVE ANALYSER

COSSOR INSTRUMENTS

These three facts behind this new symbol of supremacy in electronic instrumentation matter to you

COSSOR INSTRUMENTS

FACT 2 TWO

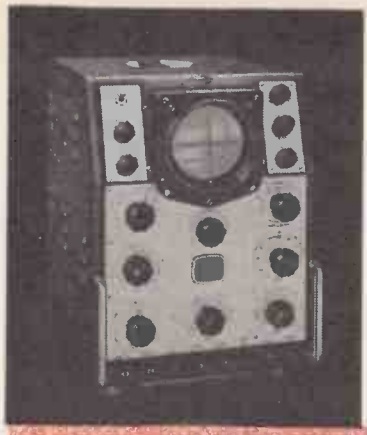
Cossor make the best and biggest range of oscilloscopes in Britain

SINGLE-BEAM OSCILLOSCOPES

MODEL 1045K
For technical colleges and radio and television servicing
response: 5c/s to 3Mc/s (-3dB)
sensitivity: 50mV/cm

MODEL 1058
General laboratory use, radio and television servicing, etc
response: DC to 4Mc/s (-3dB)
sensitivity:
max. 250mV/cm
min. 200V/cm
Calibrated time and voltage scales
TV sync separator

MODEL 1065
For fast pulse phenomena examination in TV, radar, computers and pulse circuitry
response: DC to 11Mc/s (-3dB)
sensitivity: 250mV/cm
sweep delays: 0.1msec and 1.0msec

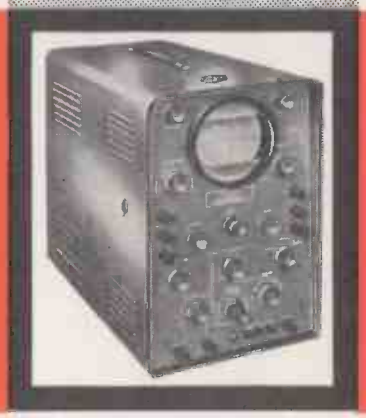


MODEL 1076
For nucleonics, communications, semi-conductor research, servo control, engineering, high-speed pulse and transient examination
response: DC to 60Mc/s (-3dB)
sensitivity: 50mV/cm
plug-in units

MONITORS

MODEL 1092
Oscillograph monitor capable of storing multiple phenomena for subsequent examination simultaneously. Storage time up to 60 days. Accessory unit to model 1049.

MODEL 1043
Also available for simultaneous identical display whilst parent instrument 1049 is obscured by camera.



MODEL 1039M
Portable for industrial and service engineering in field and workshop, for alignment of TV and FM receivers
response: 25c/s to 1.5Mc/s (-3dB)
sensitivity: 150mV/cm
weight: 10½lb

ACCESSORIES FOR OSCI

MODEL 1035
For research and industrial applications requiring high sensitivity and wide bandwidth response: (-3dB)
A1 5c/s to 5Mc/s
A2 5c/s to 250 kc/s
sensitivity: 10mV/cm

MODEL 1063
Small portable instrument for display analysis and measurement of all transducer outputs (tension, compression, hydraulic measurement) in hydraulic and pneumatic systems 0 to 50,000 p.s.i.

MODEL 1049
For servo-control, electrical engineering, vibration analysis, electro-medical instrumentation response: (-3dB)
A1 DC to 200kc/s
A2 DC to 400kc/s
sensitivity: 30mV/cm
Calibration for voltage and time

MODEL 1441
6-way transducer unit for use with hydraudyne 1063
Provides a means of quick selection of any one of six transducers connected to the equipment being tested

MODEL 1059
For precision measurements over a wide band of frequencies.
Identical Y amplifiers 1c/s to 10Mc/s (-3dB)
sensitivity calibrated 100mV/cm to 10V/cm
Internal calibration and signal delay

HYDRAUDYNE

SPLIT-BEAM OSCILLOSCOPES

PULSE TEST SET

MODEL 1091
Portable for production line testing and laboratory work
response:
DC to
3 Mc/s
(-3dB)
sensitivities:
50V-0.5V/cm

MODEL 1060
2-30 millimicrosecond pulse source and oscilloscope for transient tests up to 250Mc/s
Time Calibration
0.6 mu.sec per division

LLOSCOPES: Trolley, hoods, cameras, camera drive units, illuminated graticules, plastic covers for oscilloscopes, daylight developing tanks and film driers, video delay cable.

FACT 3 THREE

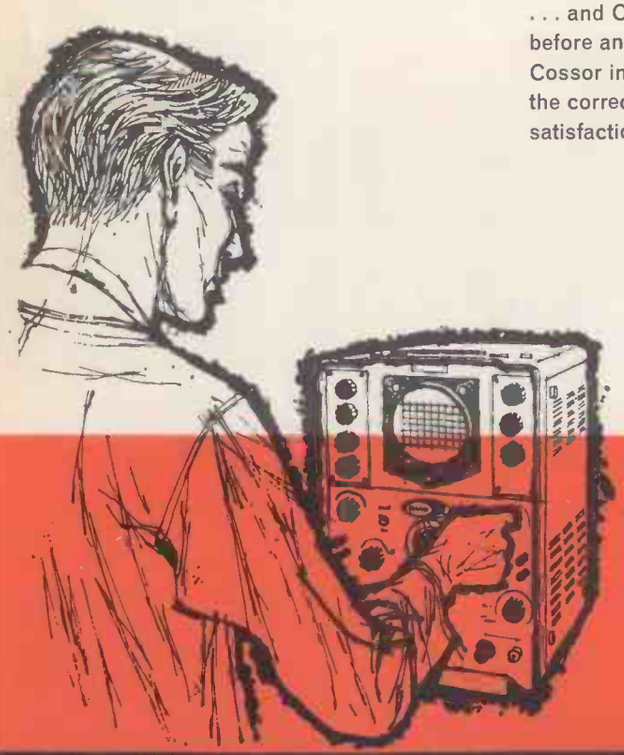
Cossor pride in fine craftsmanship ensures maximum reliability in every instrument

You will find the new Cossor Instruments' Trade-mark on a wide and fast growing range of first-class electronic products.

Cossor instruments are of advanced, but proved, electronic design and circuitry. They are manufactured and tested to the published specification and are backed by lucid and comprehensive operating and maintenance manuals. Robust, compact construction with realistic ventilation for long, continuous operation under the severest working conditions are but every-day qualities of Cossor instruments.

. . . and Cossor technical representation provides complete before and after sales advice—either as to the choice of a Cossor instrument to meet your particular requirement, or on the correct use of that instrument to perform its task to your satisfaction.

The new Cossor Trade-mark is the symbol of a superior electronic instrument, backed by first-class sales representation and service. Whenever *you* have a technical problem or doubt consult Cossor Instrument sales service.



Cossor policy pays

The Cossor policy pays you with higher efficiency and really worthwhile economy. For Cossor Instruments need the minimum of maintenance, as the numerous users of Cossor Oscilloscopes over long years will readily testify.

COSSOR INSTRUMENTS LTD., COSSOR HOUSE, HIGHBURY GROVE, LONDON, N.5 Telephone: CANonbury 1234

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Please fill in and send to the above address.

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I require technical representative to call

NAME .....

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COMPANY .....

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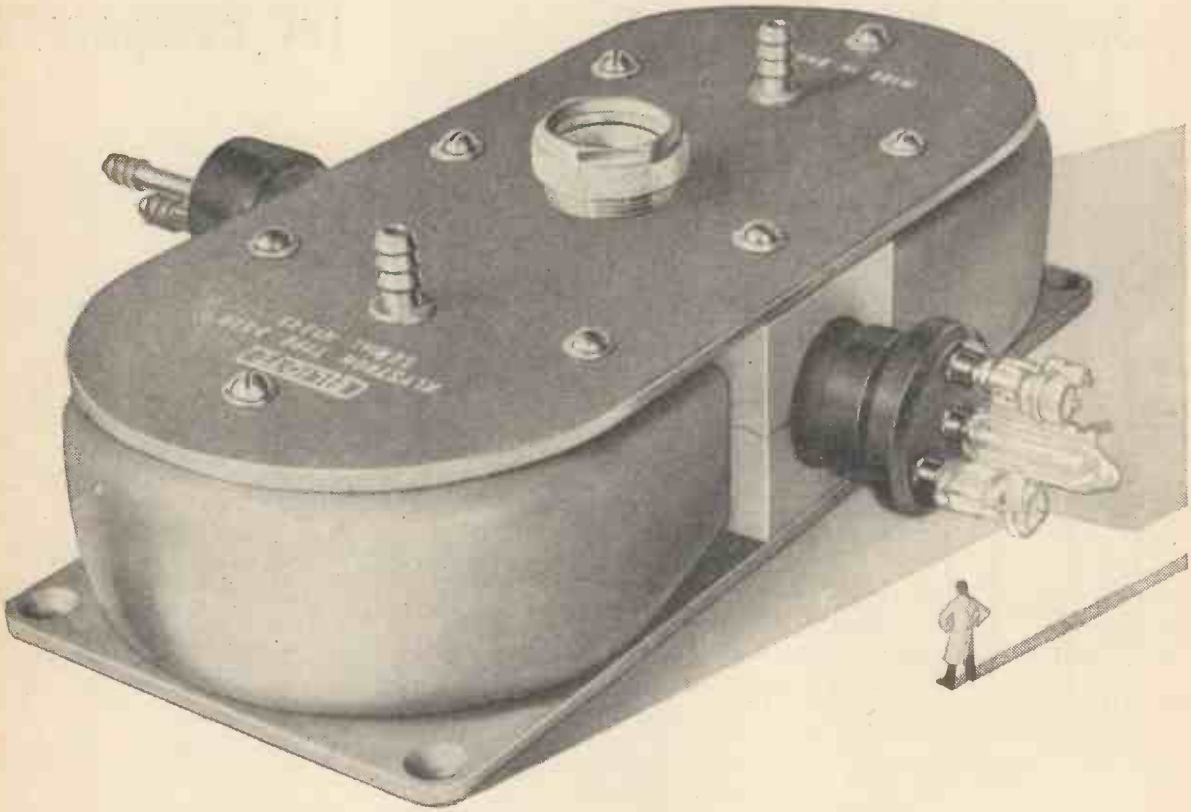
Where great things are done with Microwaves



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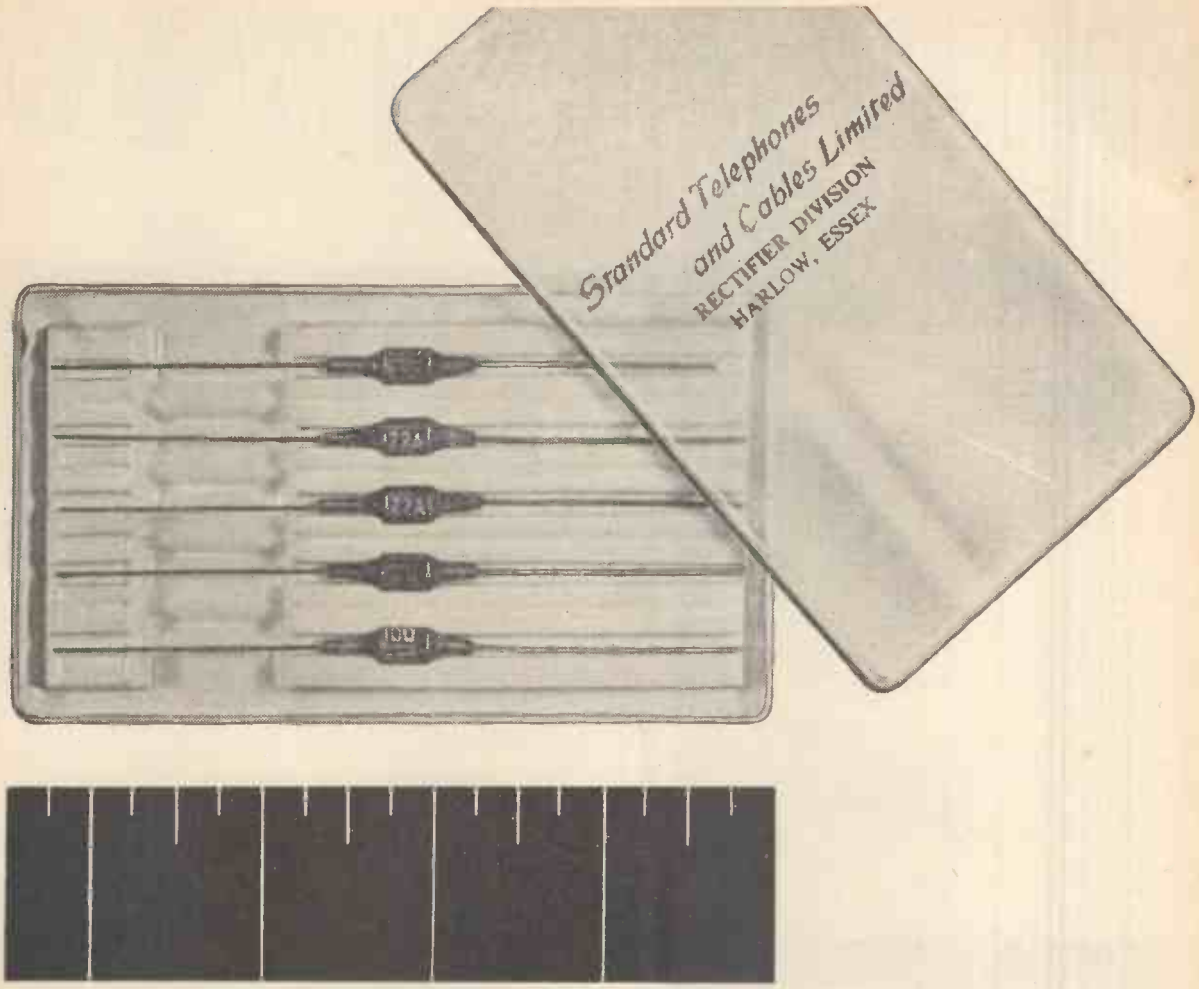

SenTerCel 1 WATT SILICON ZENER DIODES

- *Have a large dissipation for their size*
- *Are suitable for high temperature operation*
- *Have a low temperature co-efficient of voltage*
- *Are suitable for use as regulators, limiters, surge suppressors, and voltage references*
- *The first complete range of close-tolerance ZENER Diodes available from production*

Characteristics and ratings of SenTerCel Zener Diodes are given in publication MF/103

Z2 SERIES ZENER DIODES		
	TYPE	NOMINAL VOLTAGE
±5% Voltage Tolerance (Red and Green Sleeves)	Z2A33F	3.3
	Z2A36F	3.6
	Z2A39F	3.9
	Z2A43F	4.3
±10% Voltage Tolerance (Red and Yellow Sleeves)	Z2A47F	4.7
	Z2A51F	5.1
	Z2A56F	5.6
	Z2A62F	6.2
	Z2A68F	6.8
	Z2A75F	7.5
	Z2A82F	8.2
	Z2A91F	9.1
±20% Voltage Tolerance (Red and Blue Sleeves)	Z2A100F	10
	Z2A110F	11
	Z2A120F	12
	Z2A130F	13
	Z2A150F	15

STC COMPONENTS GROUP

60/4MF

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

RECTIFIER DIVISION: EDINBURGH WAY · HARLOW · ESSEX

NATIONAL RADIO SHOW·1960

AUDIO HALL

CELESTION

Trade and Public Demonstration Rm. 312

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Rola Celestion Ltd.

MANUFACTURERS ENQUIRIES ONLY

Stand No 213

LOUDSPEAKERS FOR ALL PURPOSES

Rola Celestion Ltd. THAMES DITTON, SURREY, ENGLAND. Telephone: Emberbrook 3402/6

A stable frequency source

A complete packaged oscillator unit

Stability 4 parts in 10^9

This new S T C *complete* packaged oscillator unit represents a revolutionary step forward in crystal design. It is an extremely small unit for use as a laboratory reference or as the oscillator section of high quality equipment. The ruggedness of design together with the size makes possible a degree of portability hitherto unknown in this type of unit. Standard frequency is 5Mc/s. Frequencies either side can be made to order.

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Registered Office: Connaught House, Aldwych, W.C.2.

QUARTZ CRYSTAL DIVISION: HARLOW · ESSEX

RADIO TUBES
EXPORT ONLY

Great strides are being made in all branches of the electronic industry and they are based in the main on the Radio Tube.

HALTRON have not lagged behind in this development, for we are daily adding to the number of types stocked, so that today we carry over 3,000 types of Radio Receiving, Transmitting and Special Purpose Tubes, together with Transistors.

HALTRON Tubes and Transistors are more competitive today than ever before. Contractors to Government Departments and Airlines throughout the world.

OUR ORGANISATION IS AIR REGISTRATION BOARD APPROVED.

PRICE AND STOCK LISTS ON APPLICATION.

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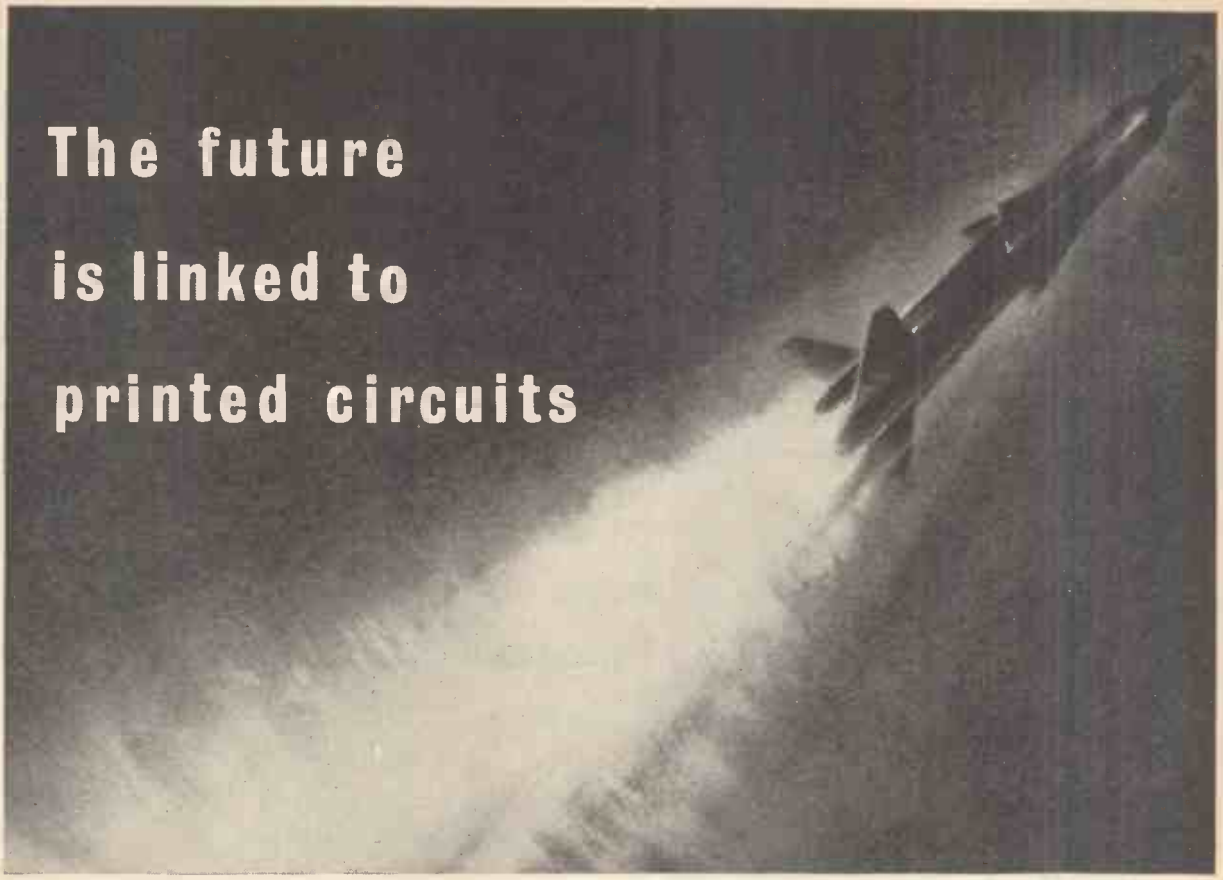
HALL ELECTRIC LTD

HALTRON HOUSE, ANGLERS LANE, LONDON N.W.5.

Tel.: Gulliver 8531 (10 lines) Telex 2-2573 Cables: "Hallectric London"

HALTRON



and in the forefront of circuitry stands Bribond

Industry stands on the threshold of a new era, with progress in electronics and nucleonics opening up limitless possibilities of process operation and production control. To the designers and manufacturers of the essential equipment, Bribond offers specialised production of printed circuits for any form of component assembly.

As pioneers of plastic lamination and experimental research in precision circuit printing, Bribond now have many advantages which linked to modern line production methods result in unsurpassed delivery service and reliability. Further, the Bribond prototype department can produce the initial circuit from which final production can be planned, within 48 hours or less if a clean circuit image is supplied for reproduction.

Bribond manufacture all forms of the printed circuit: gold, silver or rhodium plating, double-sided circuits, flexible circuits, flush circuits, resistance and magnetic circuits. Component notation, chemical milling and all forms of subsequent machining operations can be undertaken.

Your enquiries are invited. Your circuit problems, too, are welcomed especially if they pose a challenge that may call for the use of special techniques for their solution. Bribond offer design and drawing office facilities. Full details and samples are available on request.

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for Radio, Telecommunications, Electronics, Nucleonics

AYLING INDUSTRIES GROUP

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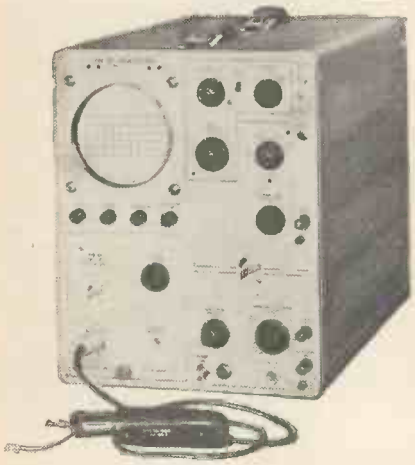
Three NEW...

TEKTRONIX®

OSCILLOSCOPES

When top performance oscilloscopes are required, the range of Tektronix instruments can satisfy the most rigorous demands. Livingston Laboratories are the sole representatives in Great Britain of Tektronix Inc.



3.5 - millimicrosecond risetime.

Type 581.

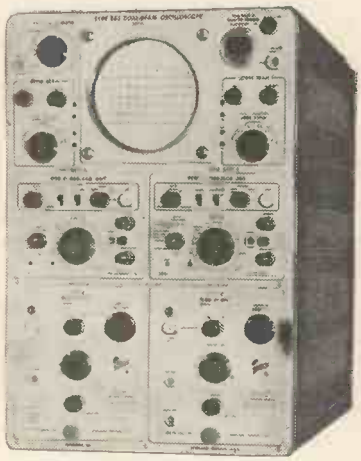
A new laboratory oscilloscope with many of the capabilities needed in the current rapid advancement of the electronic art. Its 3.5-mμ sec risetime, 0.1-v/cm sensitivity and 0.01-μsec/cm sweeptime are features for modern high-speed pulse applications. A new series of Tektronix plug-in preamplifiers promises outstanding signal-handling versatility for an oscilloscope with a vertical passband of dc to approximately 100 mc.

Type 585.

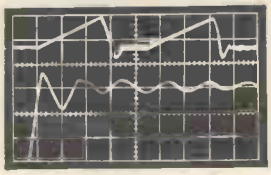
Having the identical general specifications as Type 581, the 585 has second time base generator. This acts as a sweep delay generator, providing a wide range of calibrated sweep delay, continuously variable over the range of 1μsec to 10 sec. Colour-correlated controls eliminate confusion, making this new high performance oscilloscope easy to operate.

NEW DC to 30 MC Dual - Beam Oscilloscope

Type 555.



Two electron beams, each with its own X and Y deflection systems, help make possible a highly versatile dual-beam oscilloscope. Either of the two time-base generators in the Type 555 can deflect either beam for dual and single displays, and either can deflect both beams for a dual display on the same time base. Time-base units are the plug-in type to facilitate instrument maintenance and the sweep speed is variable between 0.02 μsec/cm and 12 sec/cm. This new oscilloscope will accept the standard range of plug-in pre-amplifiers.



Same signal displayed simultaneously on slow sweep (upper beam) and fast sweep (lower beam) shows both coarse and fine structure of waveform. Delay range—0.5 μsec. to 50 secs.

Full details from

LIVINGSTON LABORATORIES LTD.

RETCAR STREET, LONDON, N.19.

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Radiotelephones by ***ATE*** *— a vital service for isolated localities*

Blazing a new trail

To drive a new highway through virgin bush country, modern machinery, equipment and materials—*and modern methods of communication*—are essential. The men on the spot can now have the benefit of a first class telephone service by radio link to supply and control centres in distant towns. For such projects the new Type 800 equipment in the ATE single channel VHF rural radio-telephone range may well prove just what the contractor needs. Exhaustively tested under arduous tropical conditions, Type 800 has already been proved thoroughly dependable and efficient.

Extended frequency coverage over VHF and UHF bands

New compact cabinet-type construction with slide-in chassis for easy access and maintenance

Plug in test meter facilities

High or low power versions to suit propagation conditions

Will work into any type of telephone exchange with improved 'outband' tone signalling facilities

Modern design conforming to G.P.O., C.O.T. and F.C.C. specifications

TYPE 800

ATE Radiotelephones are used by industrial, mining, agricultural, civil and military enterprises—and by research and survey teams—in 60 countries.

If you would like to know more about the new Type 800 equipment write for full details to your local Representative . . . or send for bulletin REB 801 to . . .

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The specialist knowledge of ATE is at your disposal—take advantage of it!

AT 14021

... and 200 miles away a telephone rings!

Eight hours ago, an expanse of barren mountainous country made communication impossible. Tonight, 60 telephone channels and teletype span the wilderness.

Transportable MICROSCATTER is a super high frequency radio system for long-range communication. Developed by Canadian Westinghouse, MICROSCATTER beams signals high above the earth sending two-way voice and teletype messages up to 200 miles over land and water . . . *without* costly relay stations.

The compact MICROSCATTER radio system fits in a standard 30 ft. truck trailer. Now, whenever men and equipment move, MICROSCATTER moves right along with them. It is particularly suited to military and government projects in remote locations. Units designed for self-contained field operations are set down by helicopter.

A Westinghouse communications specialist will be pleased to explain fully the MICROSCATTER operation and relate it to your problem. Contact your nearest Westinghouse office, or write to Canadian Westinghouse Company Limited, Electronics Division, Hamilton, Canada. YOU CAN BE *SURE* . . . IF IT'S WESTINGHOUSE.

MICROSCATTER APPLICATIONS

COMMERCIAL		MILITARY	
Fixed Station	—120 telephone channels	Wide Band	—radar
	—television and sound		—data
			—120 telephone channels
Transportable	—60 telephone channels	Tactical and Transportable	—60 voice channels
	—teletype		—teletype
			—data

FEATURES

- Frequency—4400-5000 mc
- Antennas —10 to 28 ft. diameter
- Power—2 KW
- Range—100 to 200 miles

CANADIAN

Westinghouse Microscatter

60-A-745

All eyes on the Garrard

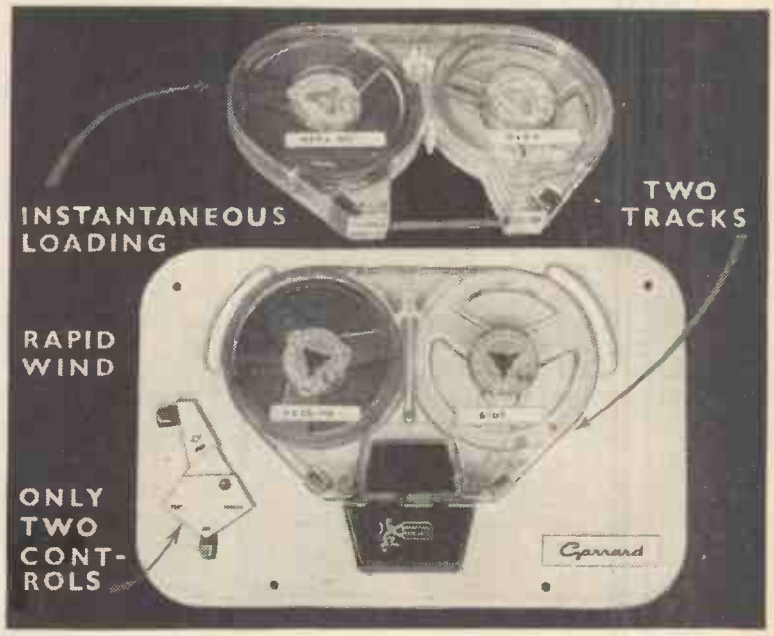
MAGAZINE TAPE DECK

So easy to operate . . .

SIMPLE—anyone can operate this deck—controls reduced to an absolute minimum.

ROBUST—no need to worry about maintenance costs. Brilliant design has removed the complications.

ELEGANT — beautifully styled to tone with modern home furnishing.



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THE GARRARD ENGINEERING AND MANUFACTURING CO. LTD.

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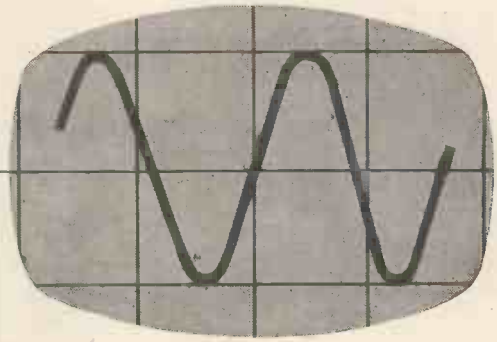
INTERKAMA

STAND No. B2025/6/D

STABILIZED SINUSOIDAL VOLTAGE



by Advance

the CVH RANGE

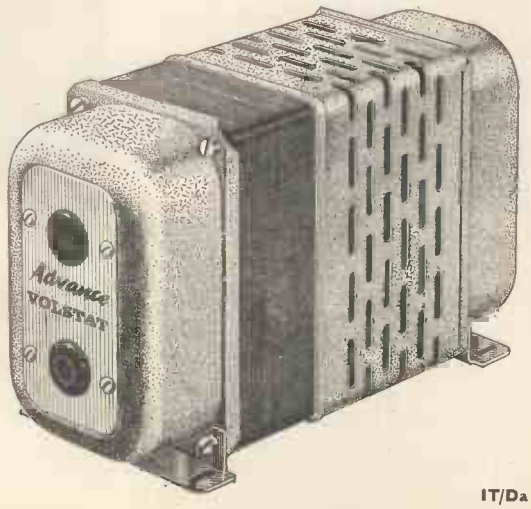
Advance constant voltage transformers are available in the CVH range with low harmonic distortion in the output waveform, ideal for use with precision equipment sensitive to power frequency harmonics, and also with all equipment requiring a constant voltage sinusoidal input.

In most applications the harmonic distortion present in the output waveform will not exceed 3%. Under the most unfavourable conditions this figure will not rise substantially above 5%. When used with a rectifier to provide a d.c. supply, the characteristics of the system are identical to the normal mains source and particularly close regulation of the output is obtained.

- CONTINUOUS AND AUTOMATIC STABILIZATION
- RAPID RESPONSE TIME
- CURRENT LIMITING CHARACTERISTIC
- COMPACT DESIGN
- NO MOVING PARTS
- NO ROUTINE MAINTENANCE

Type	I/P V Range	O/P V r.m.s.	Watts	p.f.	Net Price in U.K.
CVH60A	190–260 50 ~	240	60	1.00	£10 10
CVH125A	190–260 50 ~	240	125	1.00	£17 0
CVH420A	190–260 50 ~	240	420	1.00	£37 0
CVH750A	190–260 50 ~	240	750	1.00	£68 0
CVH1500A	190–260 50 ~	240	1,500	1.00	£99 0
CVH3000A	190–260 50 ~	240	3,000	1.00	£185 0
CVH6000A	190–260 50 ~	240	6,000	1.00	£355 0

Full details in Folder M1 available on request



Advance COMPONENTS LIMITED

MAINS STABILIZATION DIVISION

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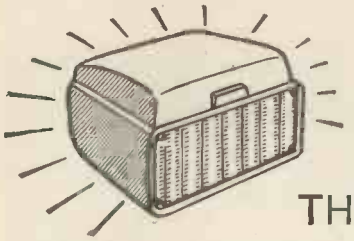
IT/Da

THEY **LOOK** SO GOOD



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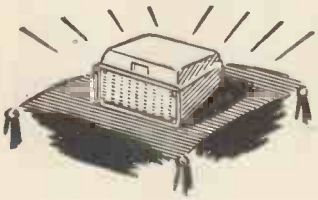

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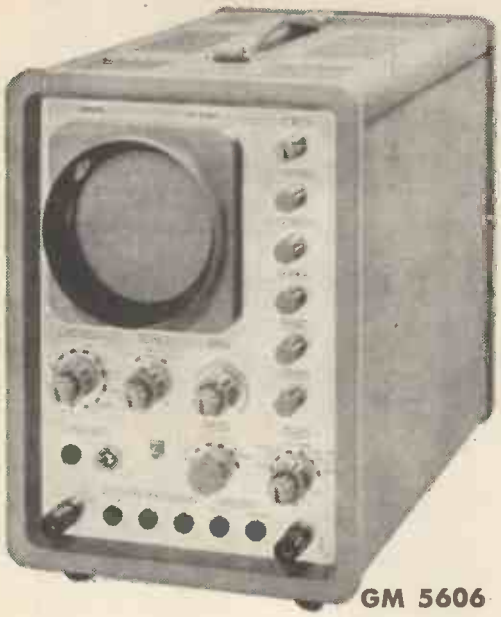

GM 5606

Low-Frequency Oscilloscope, type GM 5606

Vertical Amplifier

Bandwidth: DC - 200 kc/s (- 3 dB).
Sensitivity: 10 mVp-p/cm to 50 Vp-p/cm in 12 calibrated steps, accurate within 3%, in a 1 - 2 - 5 sequence; vernier 3 : 1 permits continuous adjustment to at least 150 Vp-p/cm.
Input impedance: 1 MΩ in parallel with 40 μμF.

Sweep range

2.5 μsec/cm - 1 sec/cm in 18 calibrated steps, accurate within 3% in a 1 - 2 - 5 sequence, x5 magnifier expands fastest sweep speed to 0.5 μsec/cm (accuracy 5%).

Trigger facilities

Internal, external or line frequency with adjustable trigger level.

Accelerating voltage: 2 kV

High-Frequency Oscilloscope, type GM 5601

Vertical Amplifier

Bandwidth: DC - 5 Mc/s (- 3 dB).
Sensitivity: 100 mVp-p/cm to 5 Vp-p/cm in 6 steps, accurate within 3%, in a 1 - 2 - 5 sequence; vernier 3 : 1 permits continuous adjustment to at least 15 Vp-p/cm. An attenuator probe 10 : 1 is delivered with the instrument.
Input impedance: 0.5 MΩ in parallel with 35 μμF.
(Probe 5 MΩ in parallel with 9 μμF).

Sweep range

0.5 μsec/cm - 200 msec/cm in 18 calibrated steps, accurate within 3% in a 1 - 2 - 5 sequence, x5 magnifier expands fastest sweep speed to 0.1 μsec/cm (accuracy 5%).

Trigger facilities

Internal, external, or line frequency with adjustable trigger level and stability control.

Accelerating voltage: 2 kV

High-Frequency Oscilloscope, type GM 5602

Vertical Amplifier

Bandwidth: 3 c/s - 14 Mc/s, (- 3 dB), risetime 25 mμsec.
Sensitivity: 75 mVp-p/cm to 10 Vp-p/cm in 7 calibrated steps, accurate within 3%, in a 1 - 2 - 5 sequence; vernier 3 : 1 permits additional attenuation to 30 V p-p/cm. An attenuator probe 10 : 1 is delivered with the instrument.
Input impedance: 0.5 MΩ in parallel with 12 μμF.
(Probe 5 MΩ in parallel with 8 μμF).
Signal delay permits viewing of the leading edge of the displayed signal in the linear portion of the time base.

Sweep range

0.2 μsec/cm - 10 msec/cm in 15 calibrated steps, accurate within 3% in a 1 - 2 - 5 sequence, x2 and x5 magnification expands fastest sweep speed to max. 40 mμsec/cm (accuracy 5%).

Trigger facilities

Internal, external or line frequency with adjustable trigger level and preset stability control.
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Accelerating voltage: 4 kV

GM 5601

instruments: quality ***tools*** for industry and research

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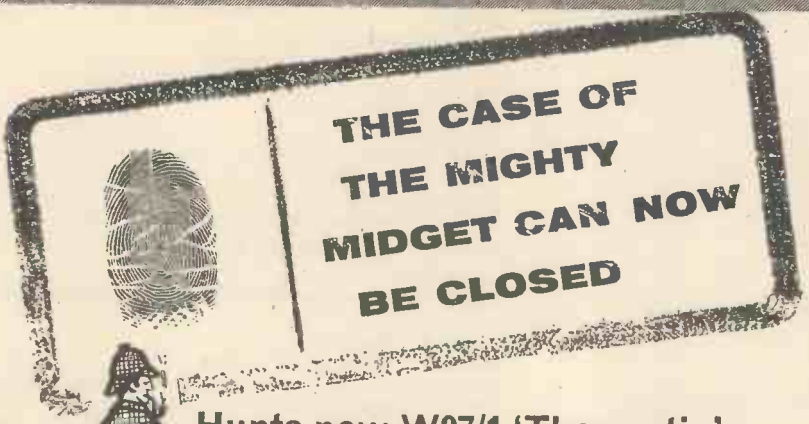

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W97/1 can be supplied also with a plastic insulating cover.

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Temperature Range	for working, -55°C to +100°C for storage, -100°C to +100°C
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Dimensions	0.500 x 0.180 inches to 0.610 x 0.260 inches
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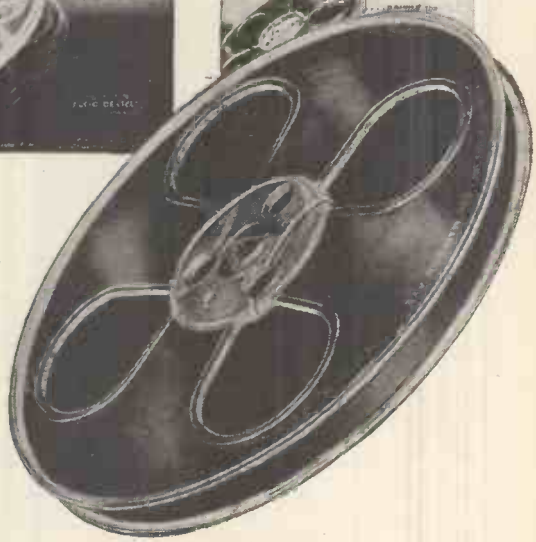

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Sweep Generator SWEEP VELOCITY: 15 ranges, 0·1 μsec/cm to 1 sec/cm at minimum expansion. TIME MEASUREMENT: 2% accuracy. TRIGGER SELECTION: A.C. coupled, D.C. coupled, TV field sync, or Automatic.

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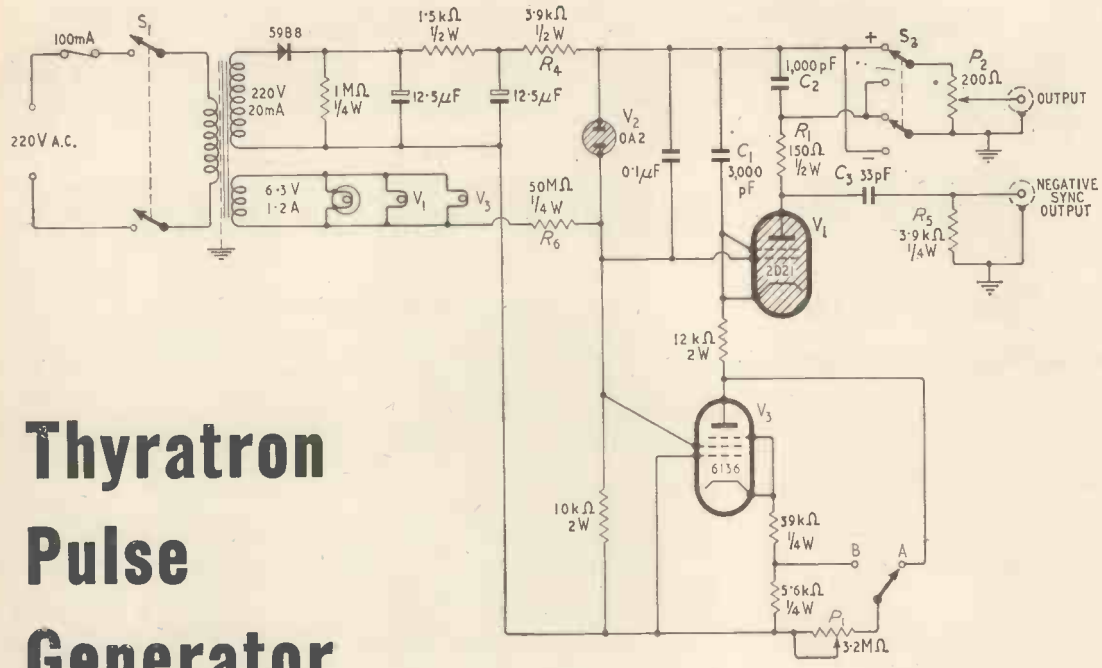
TC 154



Thyratron Pulse Generator

An article in the July issue of ELECTRONIC TECHNOLOGY describes a pulse generator which uses a thyratron as an electronic switch in a novel circuit. This generator produces short pulses of exponential shape with repetition rates from 1 c/s to 12 kc/s. The author discusses the principles of operation and gives a complete circuit description and diagram.

ARTICLES IN THE AUGUST ISSUE INCLUDE:

NEW HIGH-VACUUM TECHNIQUE

The use of an inexpensive and simple procedure for evacuating valves and other tubes is described in this article. Developed for use in teaching, it enables students to make their own valves without elaborate equipment.

TRANSISTORS IN AUDIO- AND CARRIER-FREQUENCY AMPLIFIERS

In this article, the design of amplifiers embodying transistors with heavy overall negative feedback is discussed. It is shown that by the use of a bridge circuit the input impedance can be made independent of the current amplification factor of a transistor.

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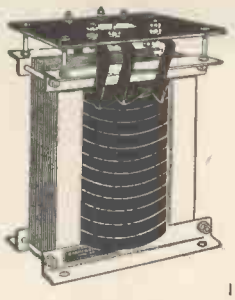

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10 V	2,000 A	£103
10 V	1,000 A	£59
10 V	900 A	£55
10 V	500 A	£38
10 V	300 A	£28
20 V	800 A	£80
20 V	3,000 A	£150
5 V	1,000 A	£39
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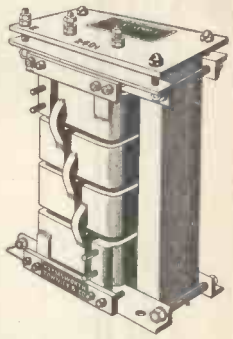

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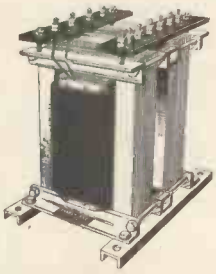

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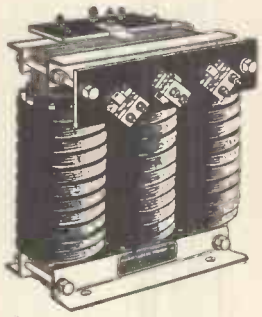

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12 V	1,000 A	£185
24 V	12 A	£23
24 V	20 A	£27
24 V	30 A	£33
24 V	60 A	£41
24 V	105 A	£70
24 V	200 A	£86
24 V	750 A	£262
36 V	10 A	£26
36 V	20 A	£32
36 V	40 A	£42
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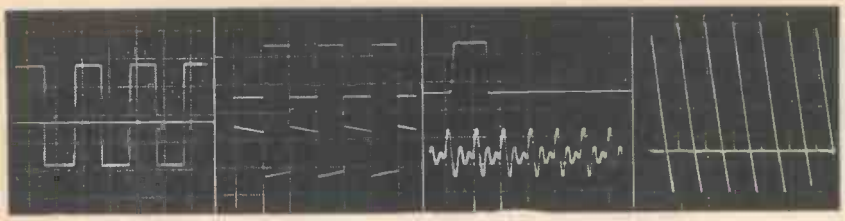

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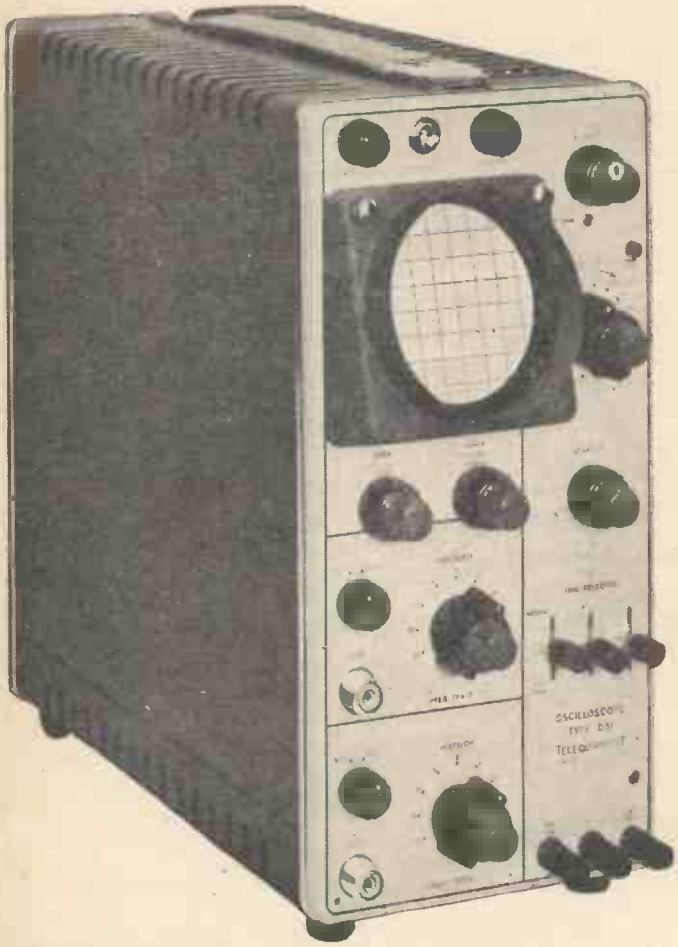

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Both per £ and per lb., each Serviscope offers greater flexibility, accuracy and reliability than any oscilloscope of comparable specification. A radical reassessment of design and production techniques has enabled smaller, lighter, instruments with many improved features to be offered giving a far higher performance than their low price would suggest.*

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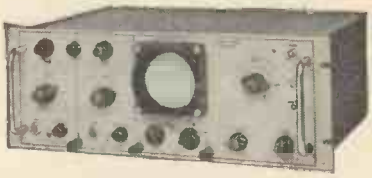

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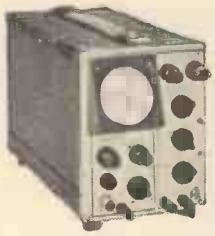

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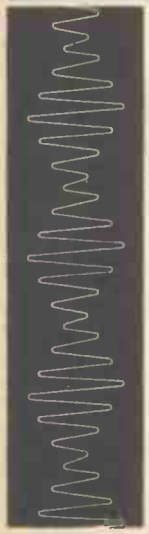

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Max. peak forward current	250 mA
Max. d.c. forward current	160 mA
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Inverse current at −150 volts:	
Maximum at 25°C	0.1 μA
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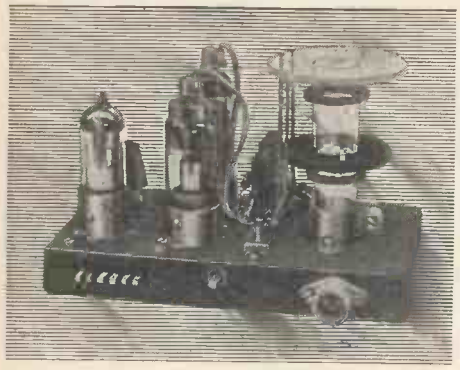

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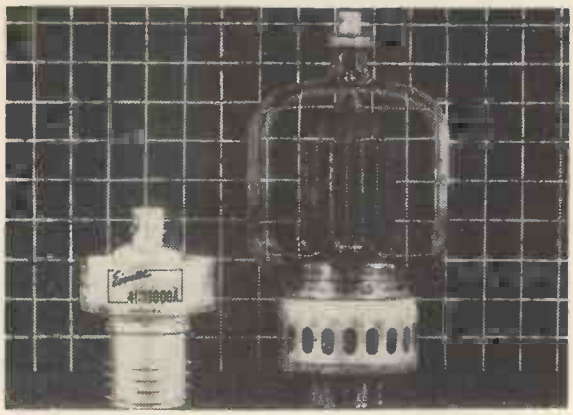

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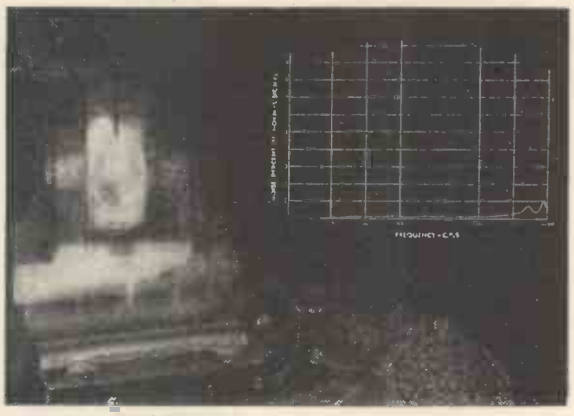

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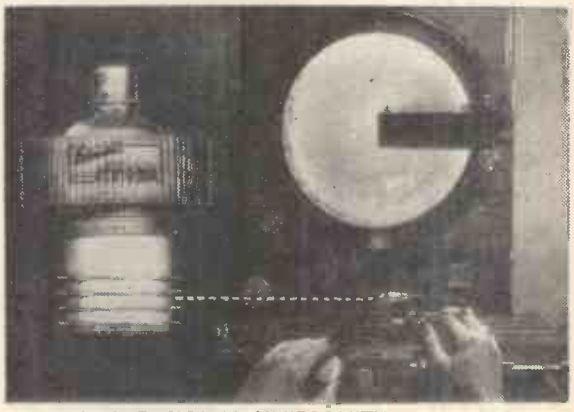

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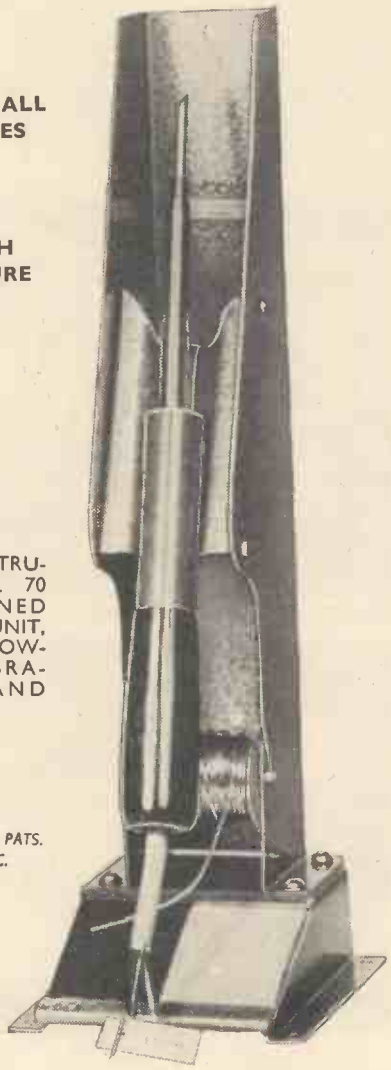

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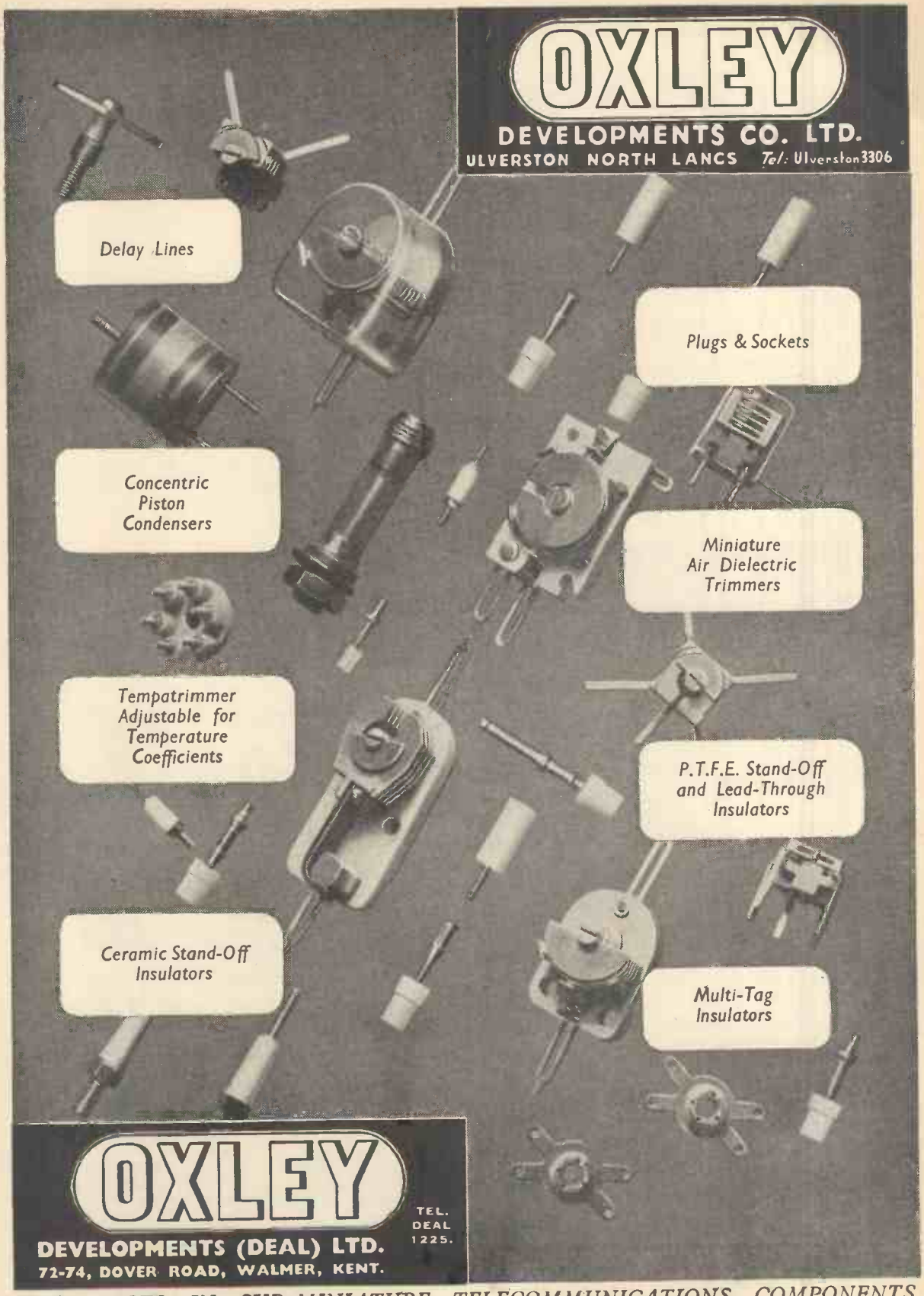

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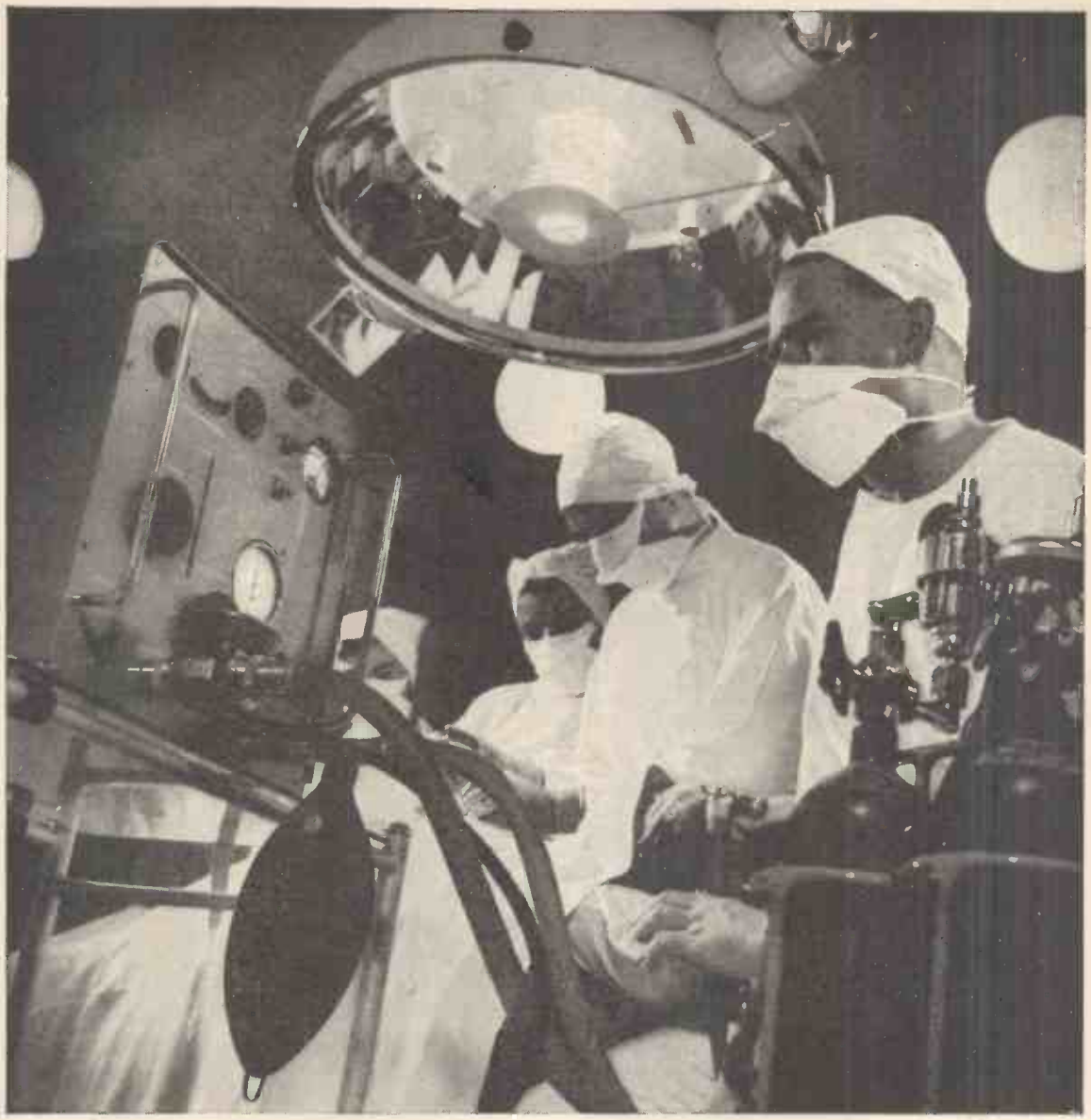

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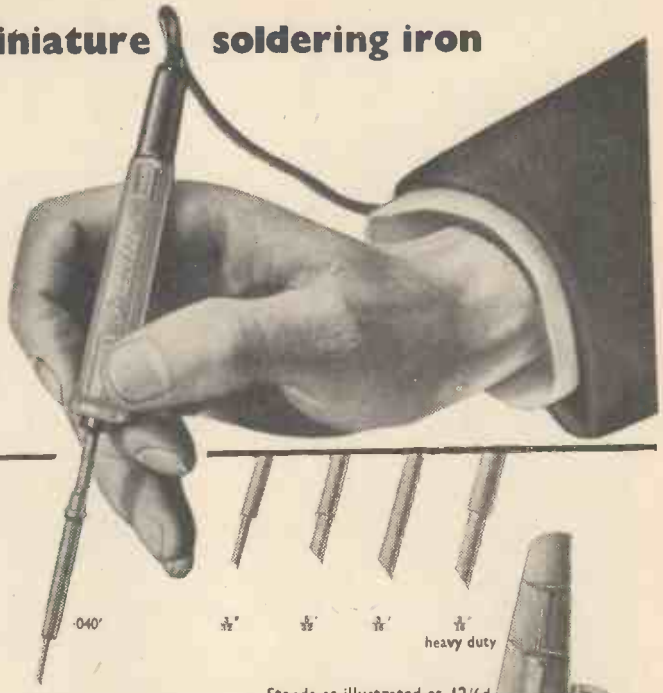

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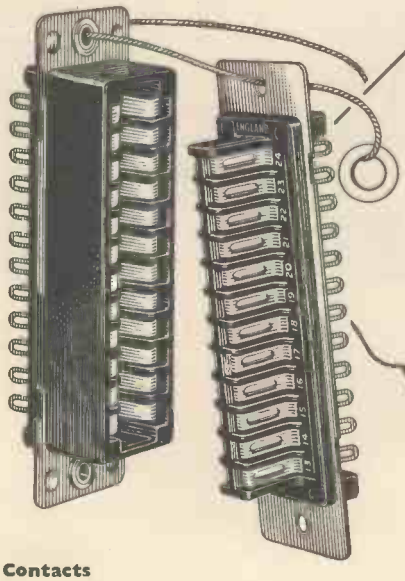

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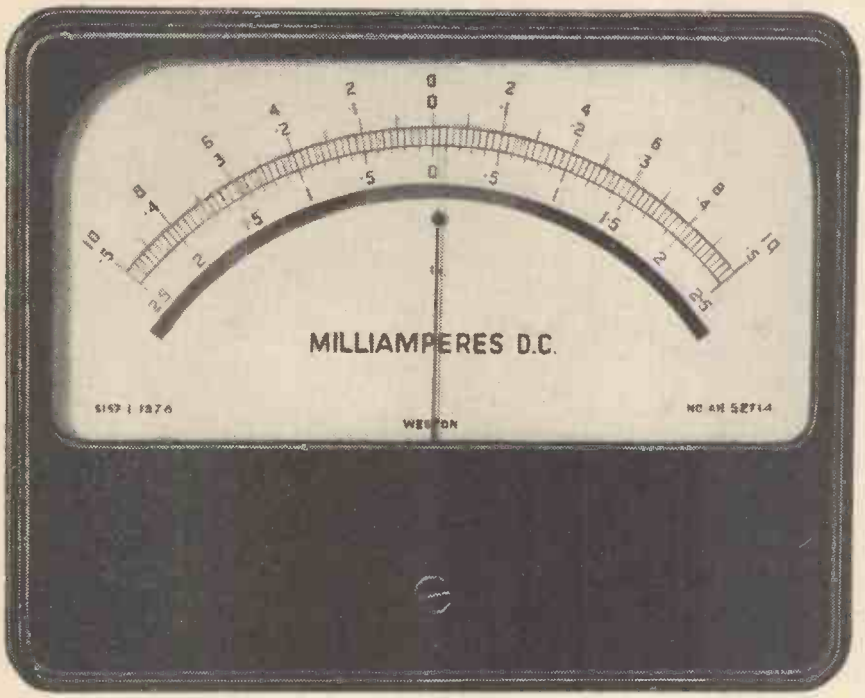

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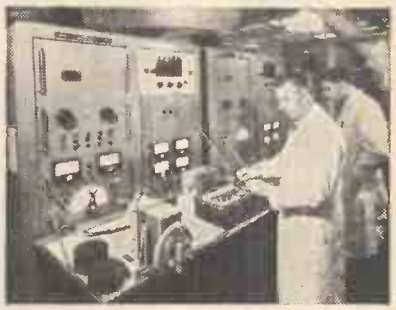

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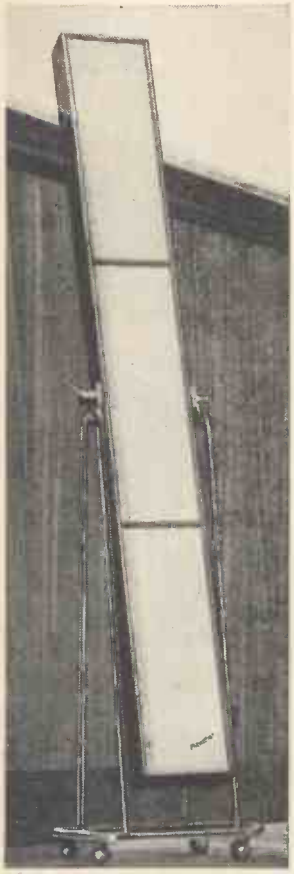

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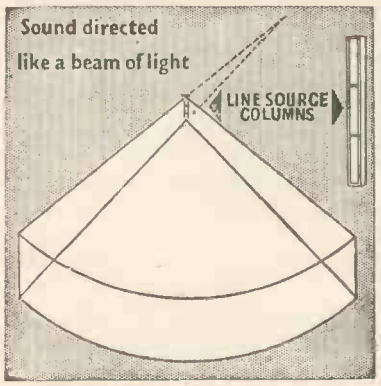

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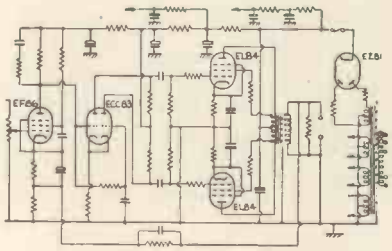

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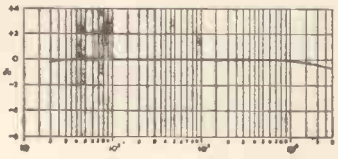

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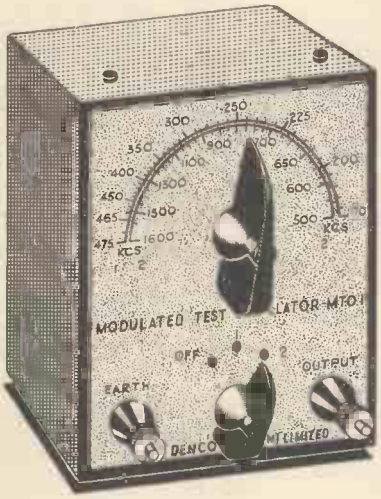

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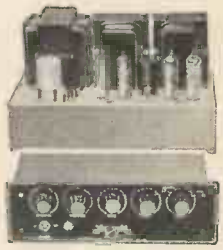
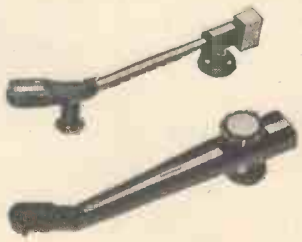
Twin channel, delivering 7.5 watts per channel with ultra linear output stage. Inputs for P.U., Tape and Radio, sensitivity being 6 mV. Separate treble and bass controls.



Stereo Pickup Mark III.

Designed to accept both monaural and stereo heads. Adjustable for heights of various turntables. Pick-up head specification identical with the Type CSI.



Stereo Pickup Type CS1.

Pick-up arm fitted with integral lifting device. The pick-up head employs miniature ceramic units, frequency range 20-16,000 c.p.s. output 20 mV. with channel separation of 20-25 dbs. Downward pressure 3½-4 grams. Diamond stylus. Will accept Mark II monaural heads.

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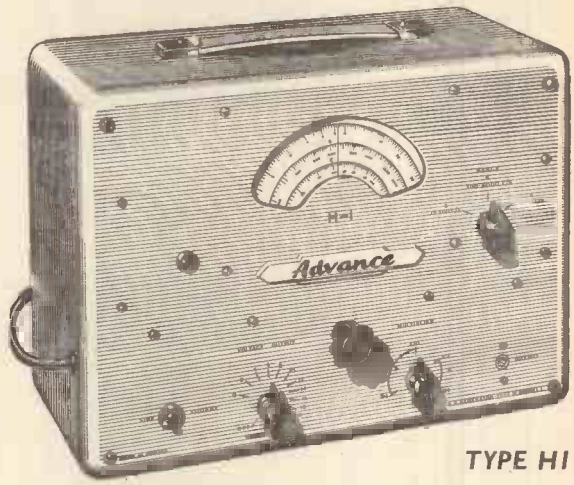
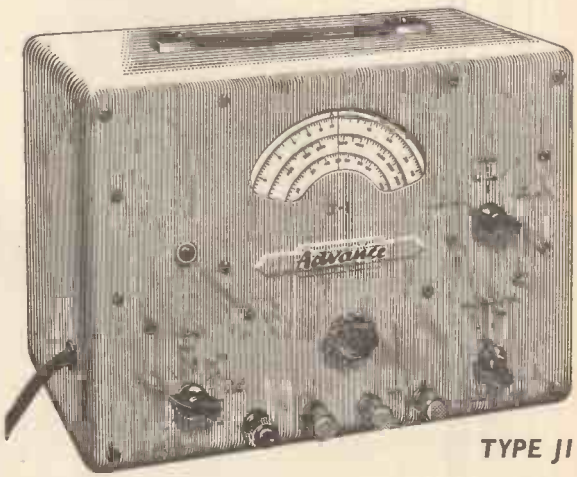


TYPE H1



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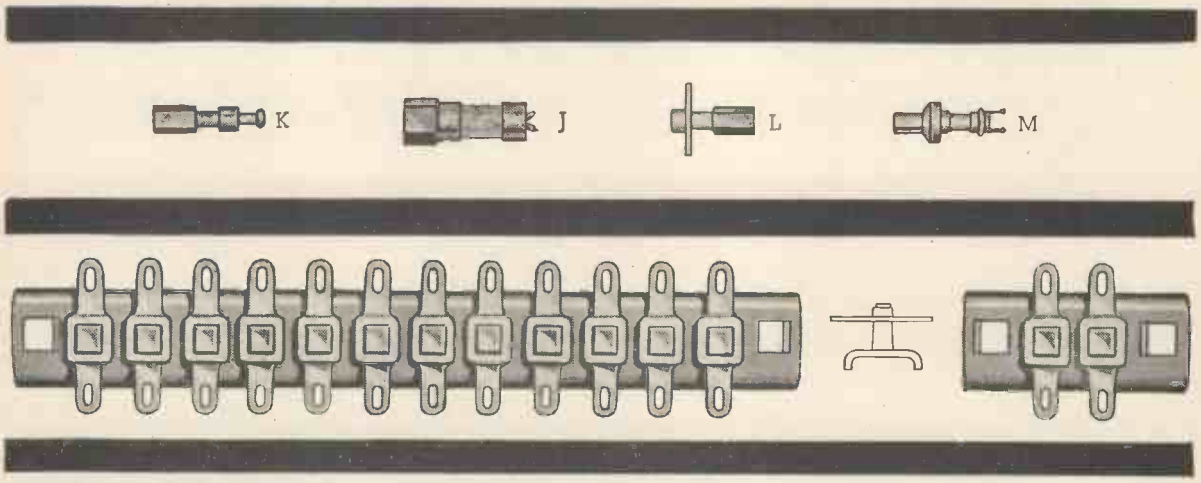

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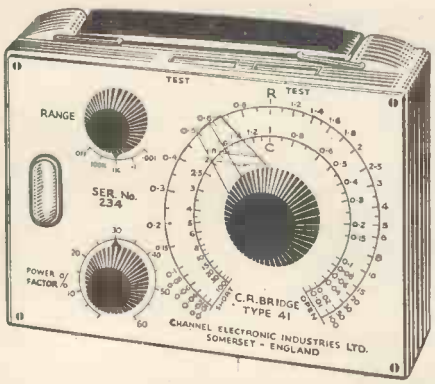

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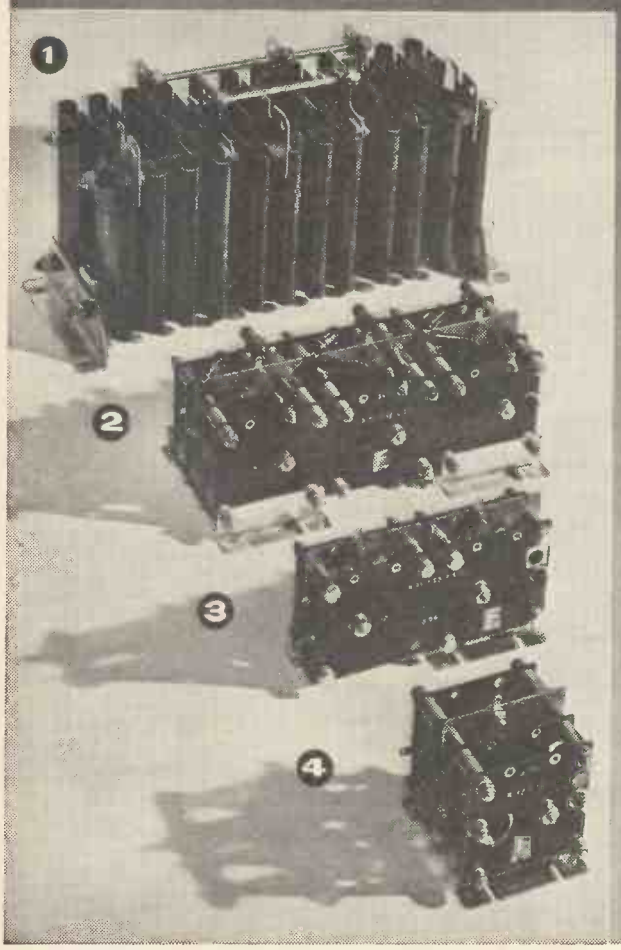

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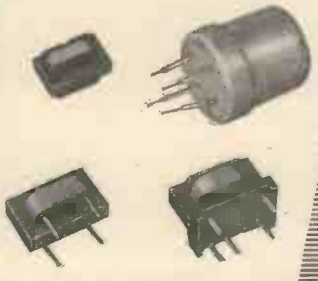

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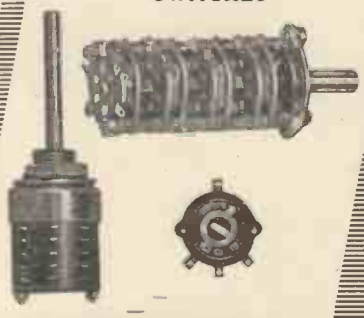

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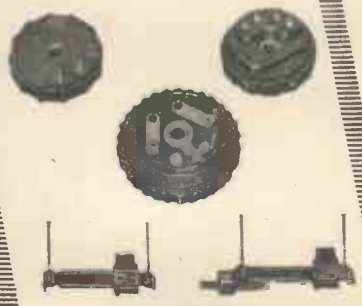

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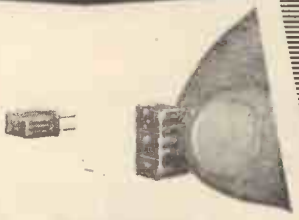

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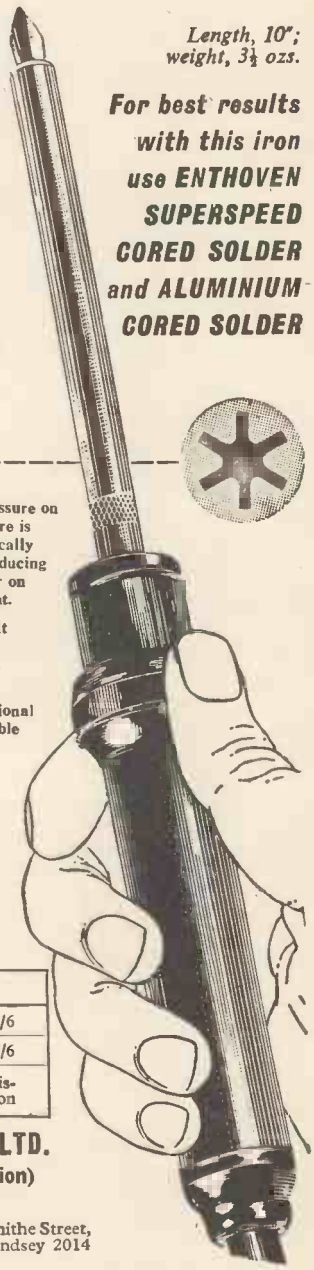

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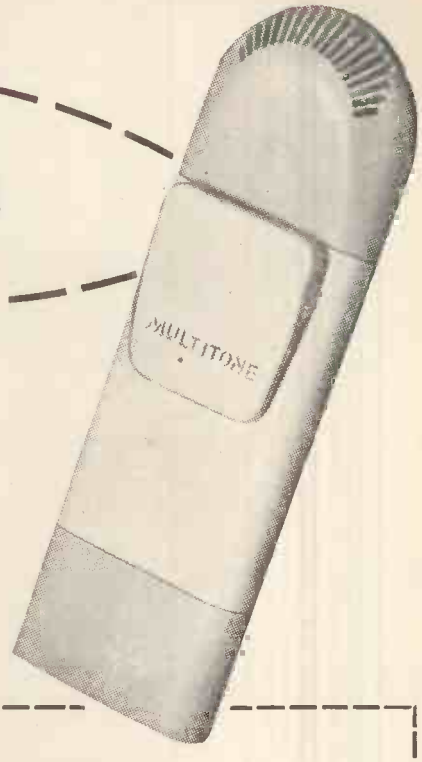

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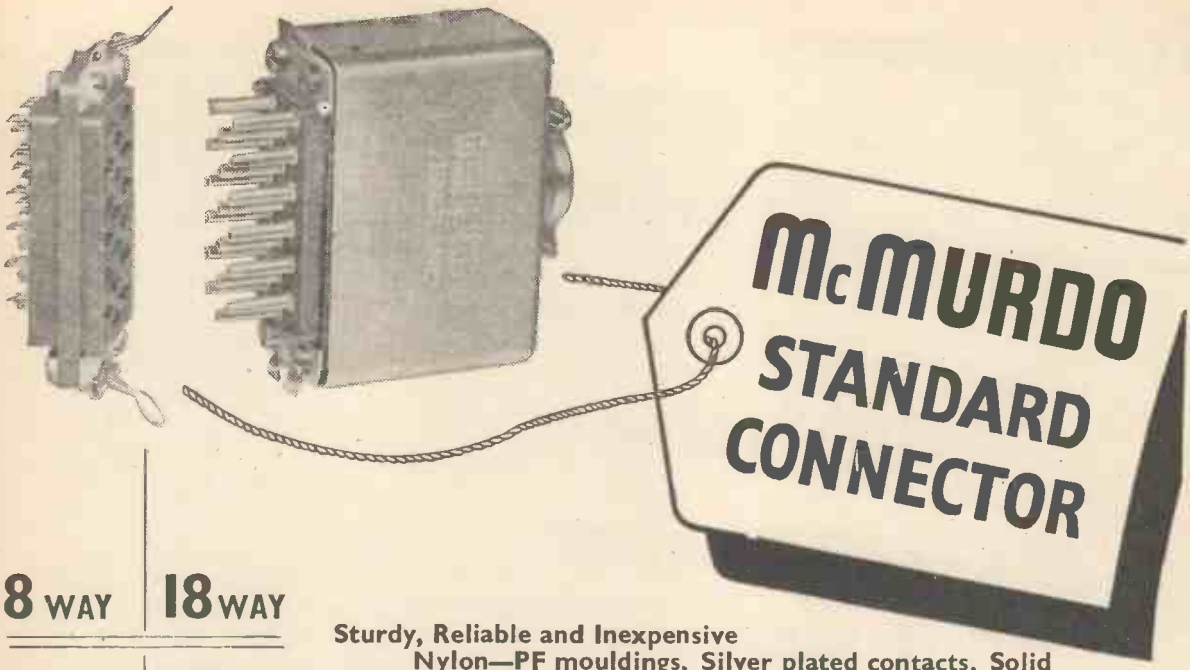

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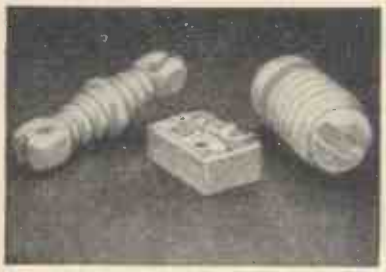

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S_x	5.0	13 V/cm
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ETL 13a

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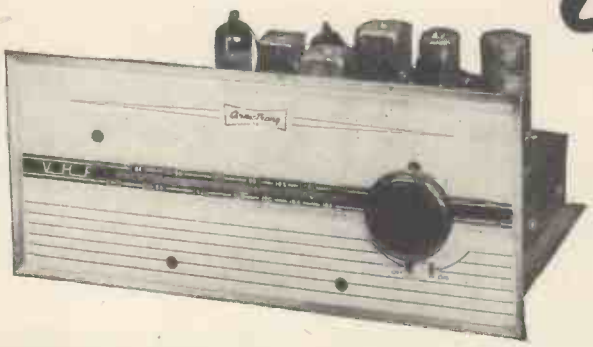

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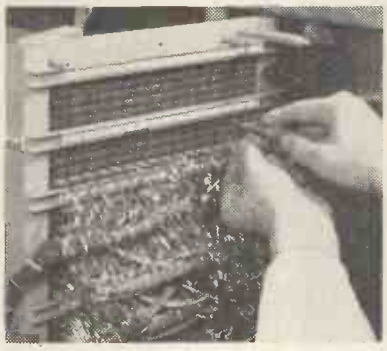

Insertion of Taper Pins on Harness into rear of wire relay plug in block.

Taper-Pin Connection.

General view of assembly shop.

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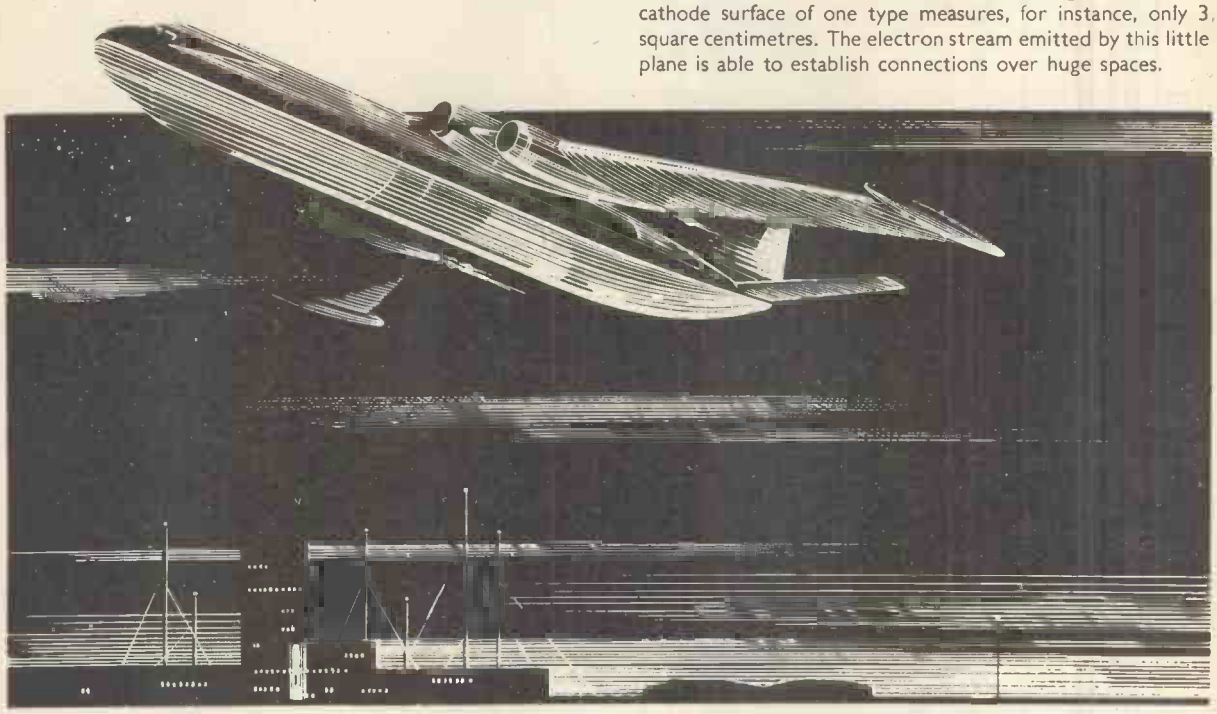

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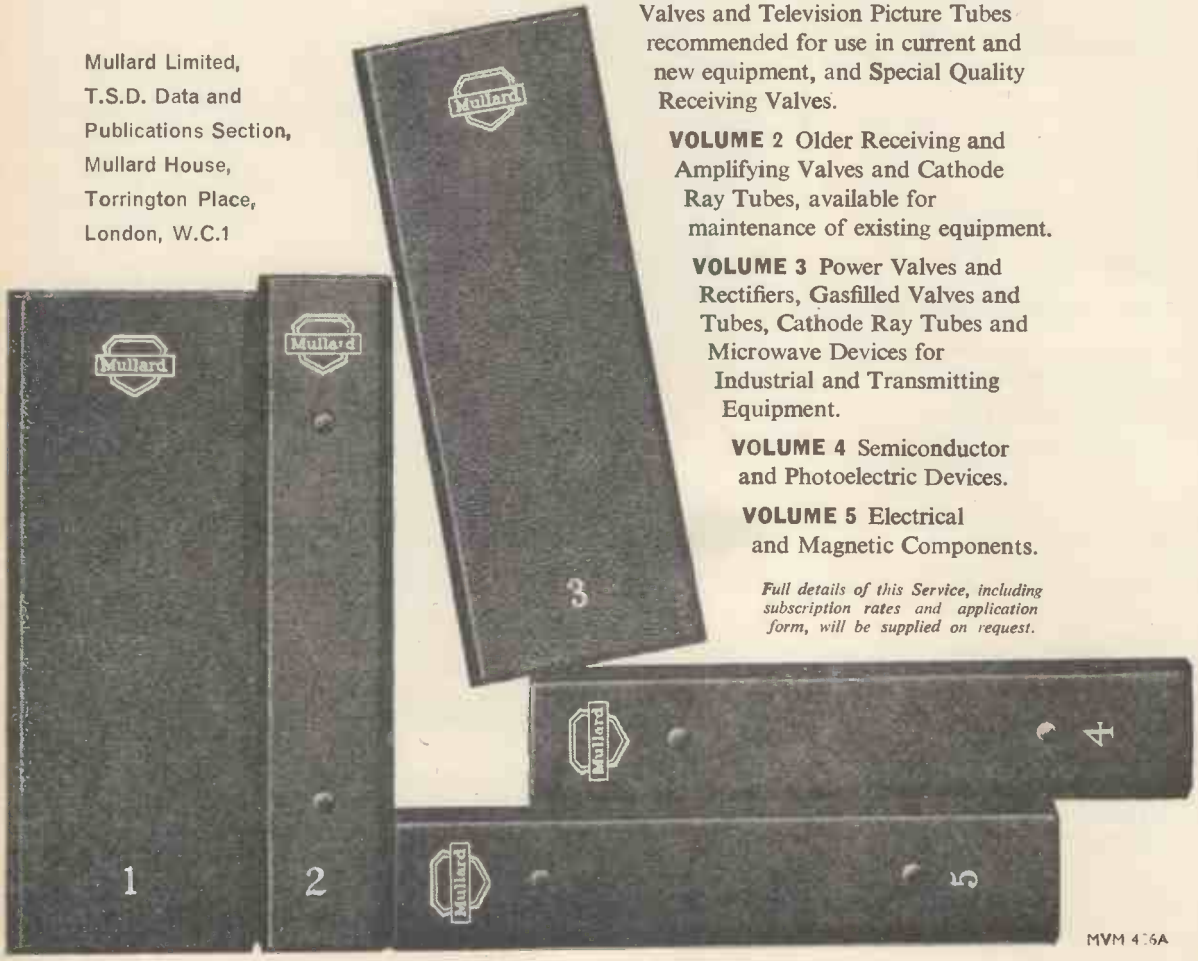

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Fusing, part 3

We have used the term "blowing" several times in previous notes on "Fusing" without saying exactly what is meant by this. It is a word with which nearly everyone is familiar in this context, but unless one has thought about it, it may be associated with a hazy mental picture of an instantaneous happening, often of some violence, whereas in fact it involves a cycle of events which occupies a measurable period of time. This, the "Operating Time", may be anything from a few microseconds to several minutes.

The blowing of a fuselink, then, is a process rather than a single event. Its duration depends on the magnitude of the overload, and also on the characteristics of the fuselink. It may be a relatively simple affair, or complex, but in either case there are two clearly defined stages involved. The first is the "cooking up" stage, during which the temperature rises to the point of fusion, followed by the circuit clearing stage; these are generally known as the "Pre-arcing", and the "Arcing" stage, respectively. The latter is virtually instantaneous if the circuit conditions preclude the maintenance of an arc, and in any case its duration is negligible by comparison if the pre-arcing stage lasts longer than 5 minutes. Its importance, however, is by no means negligible.

Fuselink performance is often expressed as a graph, where steady fusing current is plotted against operating time. Due to variations in materials, and manufacture, the operating time at a given value of current is subject to some degree of tolerance, and therefore it is customary to draw the curve in the form of an envelope whose upper and lower boundaries define the maximum permissible variations. The performance of any individual specimen will be somewhere on a straight line crossing the enveloped area from one boundary to the other. In this connection it is important to make sure that the context of the graph is appreciated, i.e., the mounting conditions, the ambient temperature and whether the performance is given in terms of a suddenly applied current, or as an overload following a period of normal running and, if so, what this was. Such curves, however, give no information about the performance under conditions of varying current nor the ability of a fuselink to withstand harmless surges, matters which we must leave for attention on some future occasion.

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The "Belling-Lee" laboratories include a fully equipped Type Test Department where, for example, mass spectrometry is employed for measuring the efficiency of seals. This is the latest technique which enables minute traces of a selected gas to be detected and accurately assessed in a matter of minutes, and renders the tracing of leakage rates as low as 10^{-6} lusec under a pressure differential of one atmosphere a workaday routine matter. With relatively little extra difficulty, leakage rates down to 10^{-10} lusec can be measured, which represents a leakage of approximately 1 c.c. in 250,000 years! The lusec, or litre, micron per second, is defined as the flow of as much gas as would produce a pressure increase of 1 micron (.001 mm.) of mercury per second in a 1 litre container, at 0°C.

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Type	Maximum Ratings					Minimum h_{FE}	Minimum f_α (Mc/s)	Maximum V_{eb} (mV)	Maximum $V_{ce(sat)}$ (mV)	Typical Transient Response (for circuit details, see data sheet)	
	$V_{cb(pk)}$ (V)	$i_{c(pk)}$ (mA)	$T_{j(w)}$ (°C)	P_t (max) (mW) 35°C	P_t (max) (mW) 55°C	$V_{ce}=-1V$, $I_c=25mA$	$V_{cb}=-6V$, $I_e=1mA$	$I_c=25mA$,	$I_b=0.83mA$	t_r (μs)	t_f (μs)
GET871	−15	150	85	75	45	20	3	400	250	0·18	0·07
GET872	−15	150	85	75	45	30	7	400	250	0·14	0·04
GET875	−15	150	85	75	45	50	15	400	250	0·12	0·04

Fuller information is available on request. G E.C. also makes a range of high-speed switching diodes, described in Semiconductor Application Report No. 14

G.E.C.

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Aspects of design

25

FM RATIO DETECTOR (PART 2)

This is the twenty-fifth of a series of special features dealing with advanced problems in television and radio circuit design to be published by The Ediswan Mazda Applications Laboratory. We will be pleased to deal with any questions arising from this or other articles, the twenty-sixth of which will appear in the September 1960 issue.

The circuit and coil details of a ratio detector circuit, designed to work with a 6LD12 or 10LD12 triple diode triode valve, are given in Figs. 1 and 2. A standard intermediate frequency of 10.7 Mc/s is used, and circuit adjustments are provided for obtaining the best possible AM rejection ratio.

The coil assembly shows provision for the 470 kc/s IF transformer which is required in a combined AM/FM receiver. In an FM receiver only, these details are of course omitted.

The following are important features of the design:—

1. A capacitive centre tap is used in the secondary circuit for making connection to the tertiary winding L3. This avoids the use of a bifilar winding, since a physical centre tap (point 7) is good enough for providing the audio take off connection.

2. The tertiary winding L3 is tightly coupled to L2 which forms part of the tuned primary circuit but is only very loosely coupled to the remainder of the primary winding L1. By adjustment of the dust iron cores in coils L1 and L2, the coupling of the tertiary winding L3 to the primary can be varied, and hence the magnitude of the tertiary voltage over a limited range. Since the ratio of tertiary voltage to secondary voltage has a pronounced effect on the balanced component of any unwanted amplitude modulation, this adjustment enables the effect of variations in the circuit to be reduced to a minimum. By making use of the dust iron tuning slugs which are available with hexagonal holes, all three coils can be mounted on the same former, and the central tuning slug which controls the inductance L2 still adjusted.

3. The capacitor C1 in series with R1 mainly affects the amount of unbalanced AM rejection in the circuit, and this is made adjustable to provide the optimum result.

4. The value of R1 quoted is the best value for use in the circuit tested, but differences in the construction or layout of the ratio detector transformer may require a different value for optimum results. Once the optimum value has been determined in any given layout, a fixed value may be used.

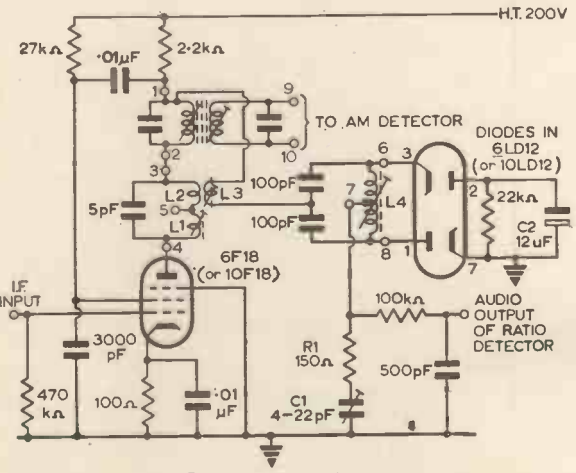
ALIGNMENT PROCEDURE

As both the tertiary inductance and the trimmer C1 affect the unwanted audio output, these controls are interdependent.

The dust iron core at the centre of the former should be initially set to lie midway between the windings L1 and L2. A signal of about 100 mV at 10.7 Mc/s should be injected into the grid of the preceding pentode valve and the dust iron slug in L1 adjusted for maximum voltage across the stabilising capacitor C2.

Using a high resistance centre zero d.c. voltmeter the secondary dust iron slug in L4 is adjusted to give zero voltage between the audio take off point and the centre of the diode load which can be provided by using two equal resistors in series for the load, or by connecting two equal high value resistors across it during measurement.

FIG. 1. F.M. RATIO DETECTOR IN COMBINED AM-FM RECEIVER



Using simultaneous amplitude and frequency modulation, the trimmer capacitor C1 is adjusted for minimum AM output (as described in Part 1). The centre iron dust slug is now moved towards the winding L2 in steps, measuring the AM rejection ratio at each step (after re-adjusting the primary and secondary tuning and the trimmer setting as required), until the required, or a maximum, value of AM rejection ratio is obtained.

The adjustment of the centre core mainly corrects for variation between transformers, and setting this for an optimum requires the use of simultaneous amplitude and frequency modulation. Once set it need not be re-adjusted if a valve is changed. Optimum AM rejection is then obtained by adjustment of the trimmer only. Since the residual AM is mainly due to the unbalanced component and this is not greatly affected by tuning, it can readily be measured by the sequential frequency and amplitude modulation method which is more simply applied.

TYPICAL PERFORMANCE FIGURES

All inputs refer to grid of valve preceding the ratio detector.

Response curve—Substantially linear to ± 100 kc/s, with peaks at approximately ± 150 kc/s.

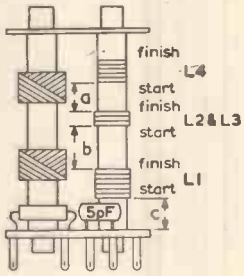
AM Rejection—< 24 dB for inputs over 35 mV.
>35 dB for inputs between 57 and 380 mV.
>35 dB over 50 kc/s tuning range using 100 mV input.

Above apply for AM frequencies between 250 and 6000 c.p.s.

Total Harmonic Distortion—< 2½% at 75 kc/s deviation for ± 30 kc/s detuning.

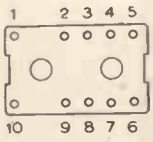
Diode cut-off—Circuit handles downward amplitude modulation up to 45% at 100 mV input.

WINDING DETAILS OF F.M. COILS



Dimensions
a—9.5 mm.
b—14 mm
c—4 mm

FIG. 2.
BASE PIN CONNECTIONS
VIEWED FROM UNDERNEATH



L1—47 turns 38 SWG ESS. Start to pin 4, finish to pin 5.

L2—12 turns 38 SWG ESS. Start to pin 5, finish to pin 3.

L3—12½ turns 38 SWG ESS (wound on 1½ turns .002″ acetate film over L2). Start to the junction of the two 100 pF capacitors. Finish to pin 1.

L4—22 turns of 38 SWG ESS, centre tapped. Start to pin 6, centre tap to pin 7, finish to pin 8.

100 pF capacitors are in series between pins 6 and 8.
5 pF capacitor between pins 3 and 4.

Former is polystyrene 0.3″ O.D. threaded to take iron dust cores 6 mm. dia. × 12.5 mm. long, 0.75 mm. thread, with hexagonal trimming holes.

Can be 1⅝″ long × 1″ wide × 2 11/16″ high.

Associated Electrical Industries Ltd
Radio and Electronic Components Division
Technical Service Department
155 Charing Cross Road, London, W.C.2
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EDISWAN MAZDA 6LD12

The 6LD12 is a Triple Diode Triode intended for use in FM and AM/FM a.c. mains receivers. The first diode is for AM detection with the second and third diodes designed for use as the FM ratio detector. The high μ triode is for audio amplification.

Heater Voltage (volts) V_h 6.3
Heater Current (amps) I_h 0.45

MAXIMUM DESIGN CENTRE RATINGS

Triode Section

Anode Dissipation (watts)	$P_{a(t)max}$	1
Anode Voltage (volts)	$V_{a(t)max}$	300
Heater to Cathode Voltage (volts d.c.)	$V_{h-k(t)max}$	150
Cathode Current (mA)	$I_{k(t)max}$	5

Diode Sections

Peak Inverse Voltage (all sections) volts	$PIV_{(max)}$	350
Anode Current. Section 1 (mA)	$I_{a'(d)}$	1
Anode Current. Section 2 (mA)	$I_{a''(d)}$	10
Anode Current. Section 3 (mA)	$I_{a'''(d)}$	10

CHARACTERISTICS

Anode Voltage (volts)	$V_{a(t)}$	100
Grid Voltage (volts)	V_g	−1
Anode Current (mA)	$I_{a(t)}$	0.8
Mutual Conductance (mA/V)	g_m	1.45
Amplification Factor	μ	70
Ratio Anode Resistance ($\delta v_a/\delta i_a$) Diode 2 to Diode 3	$r_{a''d}/r_{a'''d}$	0.65 to 1.5

INTER-ELECTRODE CAPACITANCES (pF)

		*	**	***
Triode Section				
Anode/Earth	C_{a-E}	1.4	1.9	2.6
Grid/Earth	C_{g-E}	1.9	2.2	3.0
Grid/Anode	C_{g-a}	2.0	2.1	2.4
Diode Sections				
Cathode, Diode 2/all	$C_{k''d-all}$	4.9	5.3	6.4
Anode Diode 3/all	$C_{a'''d-all}$	5.1	5.6	6.6
Anode Diode 1/h, pin 7	$C_{a'd-kt.\ k'd\ k'''d.\ h.\ s}$	0.8	1.1	1.7
Anode Diode 2/h, pin 7, Cathode Diode 2	$C_{a''d-k'd.\ kt.\ k'd.\ k'''d.\ h\ s}$	4.8	5.0	5.4
Cross Capacitances				
Anode/Anode Diode 1	$C_{at-a'd}$	0.08	0.09	0.10
Anode/Anode Diode 3	$C_{at-a'''d}$	0.05	0.11	0.22
Anode/Cathode Diode 2	$C_{at-k''d}$	0.006	0.011	0.016
Grid/Anode Diode 1	$C_{g-a'd}$	0.06	0.07	0.10
Grid/Anode Diode 3	$C_{g-a'''d}$	0.012	0.021	0.035
Grid/Cathode Diode 2	$C_{g-k''d}$	0.0025	0.0044	0.0066

*Inter-electrode capacitance in fully shielded socket, without can.

**Inter-electrode capacitance with holder balanced out (using holder quoted below).

***Total inter-electrode capacitance including B9A nylon phenolic holder without skirt or radial shield (AEI Clix holder Type VH19/902).

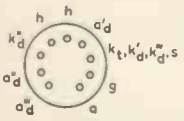
TYPICAL OPERATING CONDITIONS AS RESISTANCE CAPACITY COUPLED AF AMPLIFIER

(Grid Current Bias)

Supply Voltage (volts)	$V_{a(b)}$	170	170	170	200	200	200
Anode Load Resistance (kΩ)	R_a	47	100	220	47	100	220
Grid Resistor (Grid Current Bias) (MΩ)	R_{g1}	10	10	10	10	10	10
Anode Current (mA)	I_a	1.25	0.82	0.46	1.6	1.0	0.56
Grid Resistor of following valve (kΩ)		150	330	680	150	330	680
Voltage Amplification		32	42	51	34	44	53
Total Distortion for 3 volts (rms) output (%)		0.6	0.5	0.4	0.5	0.4	0.3
Total Distortion for 5 volts (rms) output (%)		1.1	0.8	0.5	0.9	0.6	0.4
Total Distortion for 8 volts (rms) output (%)		2.0	1.3	1.1	1.5	1.0	0.9

Maximum Dimensions (mm)

Overall Length	67.5
Seated Height	60.5
Diameter	22.2



BASE B9A (Noval)

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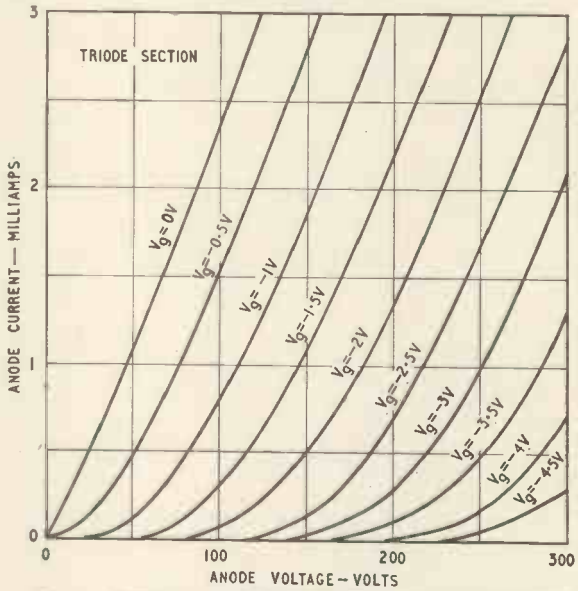
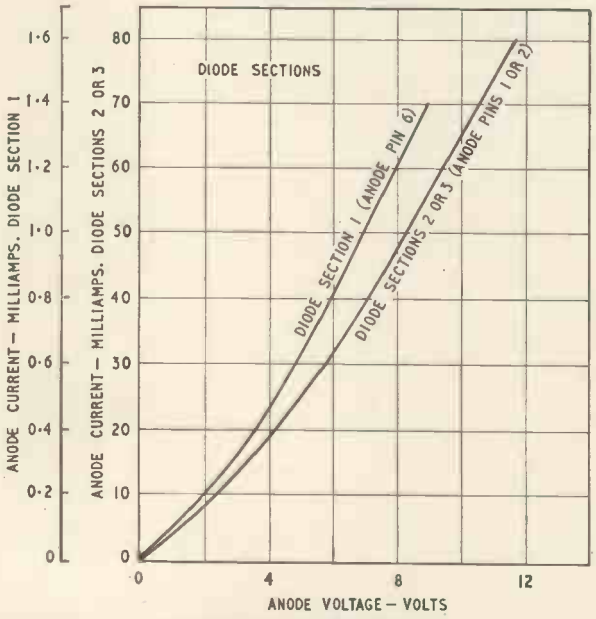
Characteristic curves of Ediswan Mazda Valve Type 6LD12





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The AD 712 uses a ferrite cored fixed loop aerial which has no moving parts and is considerably more sensitive than any other ADF loop in use today.

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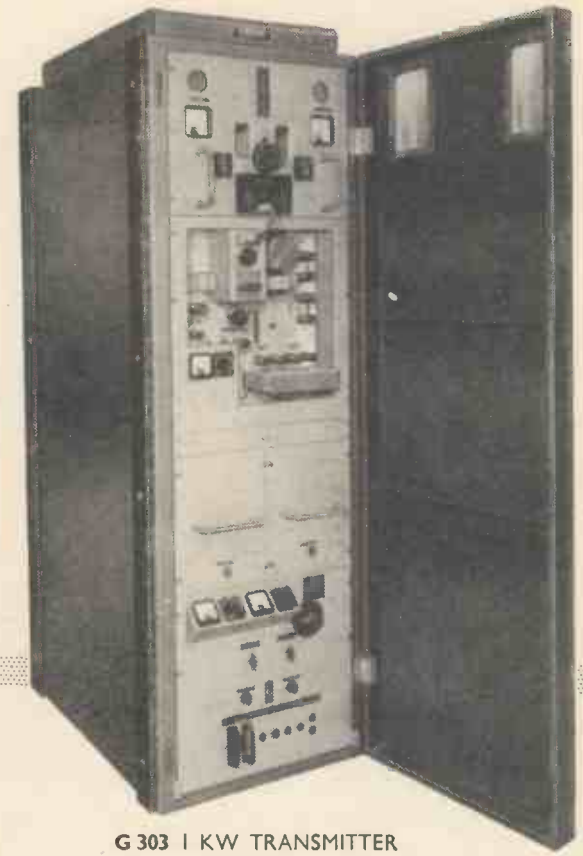

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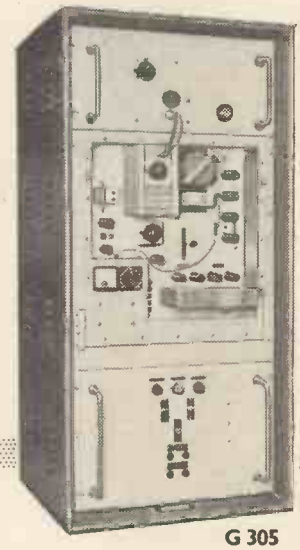

G 305
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TYPE	gm (mA/V)	Ca—all less gl (pF)	Cgl—all less a (pF)	Pa (pF)
Z319	19	3	8	2.5
Z759	15	3	13	5
417A	25	0.35	6.5	4
R5559	25	5	12	4.5
A2674	32	3.5	15	4.5

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TYPE 201 the new compact camera channel

A new vidicon camera channel, which offers considerable economy of operation, and has been specially designed to meet the needs of broadcasting organisations throughout the world, has now been added to the E.M.I. range.

Known as the Type 201, this channel has been found particularly suitable for interviews and live news programmes where the use in the studio of a larger Image Orthicon or CPS camera is not justified. It is also of great value as a fill-in camera for outside broadcasts under suitable lighting conditions. The channel is designed for use with E.M.I. vidicon tube 10667S or equivalents, such as the R.C.A. vidicon 6326.

The complete channel comprises the camera Type 201 and Camera Control Unit Type 211. The principal controls on the Control Unit can be operated remotely using a Remote Control Panel Type 216. Unattended operation of the camera can be achieved by fitting a motorised variable focus lens and mounting the camera on the new E.M.I. remotely controlled Pan and Tilt Unit.

The same channel is used in the new Telecine Equipment Type 404.

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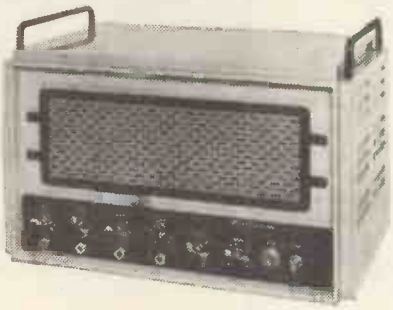


It is available in our standard steel case with Baxendale tone controls and up to 4 mixed inputs, which may be balanced line 30 ohm microphones or equalised P.U.s to choice.

ELECTRONIC MIXER/AMPLIFIER

This high fidelity 10/15 watt Ultra Linear Amplifier has a built-in mixer and Baxendale tone controls. The standard model has 4 inputs, two for balanced 30 ohm microphones, one for pick-up C.C.I.R. compensated and one for tape or radio input. Alternative or additional inputs are available to special order. A feed direct out from the mixer is standard and output impedances of 4-8-16 ohms or 100 volt line are to choice. All inputs and outputs are at the rear and it has been designed for cool continuous operation either on 19 x 7in. rack panel form or in standard ventilated steel case.

Size 18 x 7½ x 9½in. deep.

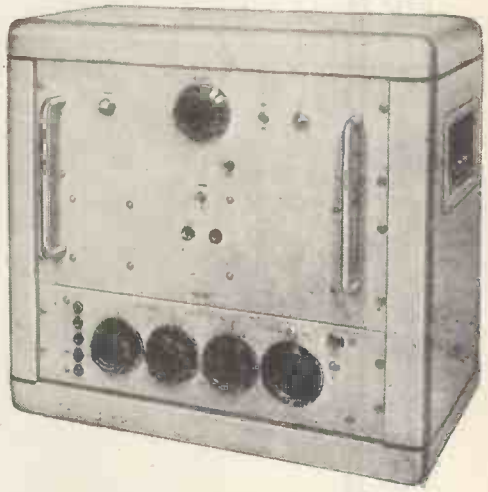
Price of standard model **£49.**

Also 3-way mixers and Peak Programme Meters.

4-way mixers.

12-way mixers, and 2 x 5-way stereo mixers with outputs for echo chambers, etc. Details on request.

120/200 WATT AMPLIFIER



Will deliver 120 watts continuous signal and over 200 watts peak Audio. It is completely stable with any type of load and may be used to drive motors or other devices to over 120 watts at frequencies from 20,000 down to 30 cps in standard form or other frequencies to order. The distortion is less than 0.2% and the noise level —95 dB. A floating series parallel output is provided for 100-120 V. or 200-250 V. and this cool running amplifier occupies 12¼ inches of standard rack space by 11 inches deep. Weight 60lb.

Full details and prices of the above on request

VORTEXION LIMITED, 257-263 The Broadway, Wimbledon, London, S.W.19

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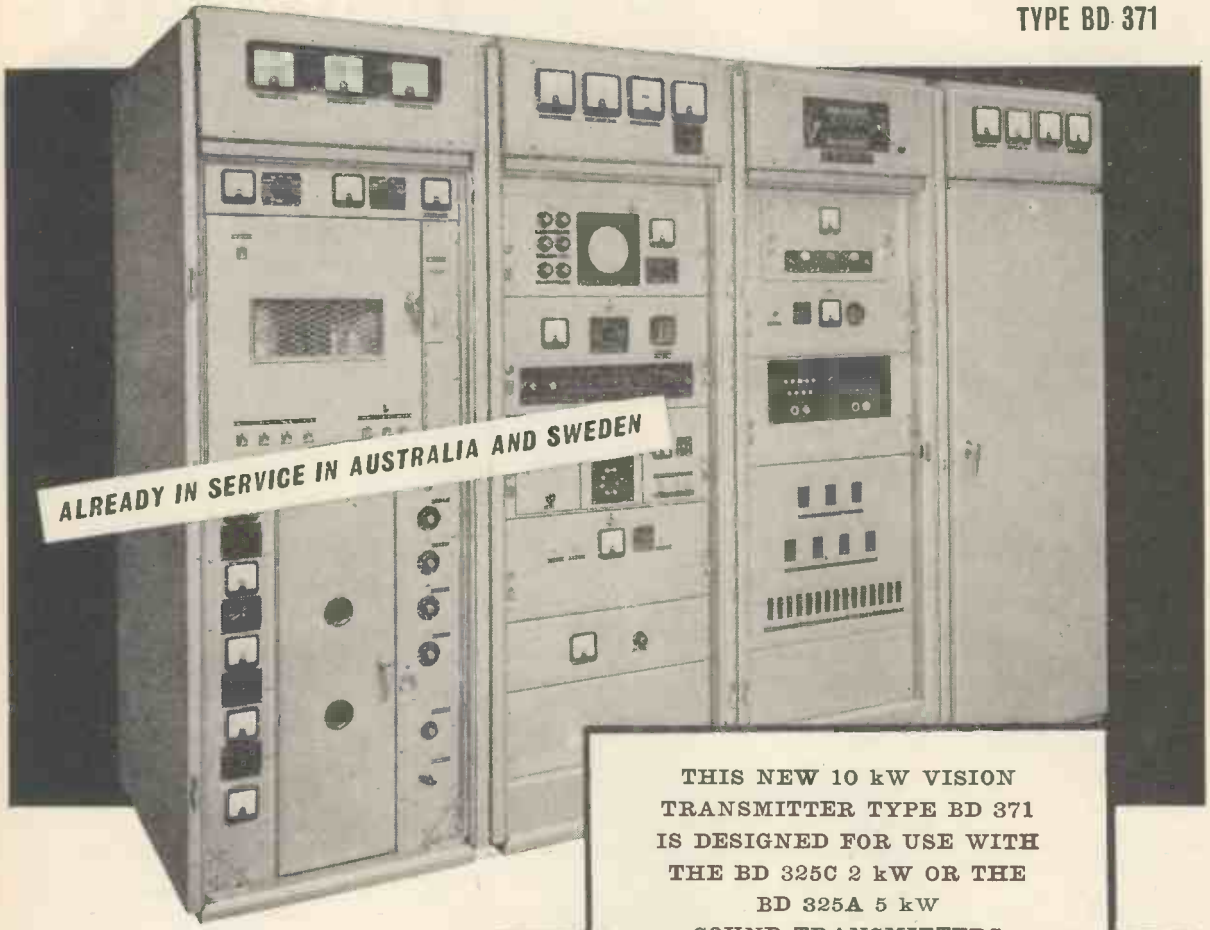
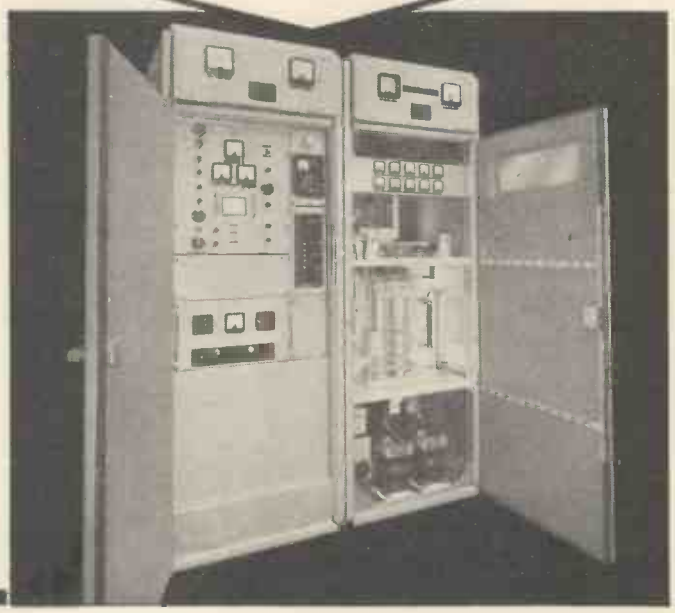
NEW Marconi 10 kW Band 1 Television Transmitter

TYPE BD 371



THIS NEW 10 kW VISION TRANSMITTER TYPE BD 371 IS DESIGNED FOR USE WITH THE BD 325C 2 kW OR THE BD 325A 5 kW SOUND TRANSMITTERS

- Suitable for unattended operation.
- Adapted for parallel operation.
- Minimum floor space requirement.
- No underfloor ducts.
- Low cost installation.
- Minimum number of RF stages.



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This technical lead resulted in a demand for LEAK amplifiers from professional engineers in the B.B.C. (over 500 delivered), the South African Broadcasting Corporation (600), ITV and many other Commonwealth and Overseas broadcasting and TV systems, who use them for transmitting and/or monitoring broadcasts. Also, many gramophone records are cut via LEAK Amplifiers. This acceptance by professional engineers led to a demand from music-lovers throughout the world.

The concentrating of our resources exclusively on Hi-Fi equipment and our world-wide market enables us to offer the best equipment at the lowest prices.

The New "Varislope Stereo"

The New "Varislope Stereo" pre-amplifier incorporates facilities which make it the most comprehensive pre-amplifier presently available.

Price **£25**

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- VARISLOPE III PRE-AMPLIFIER
- TL/12 PLUS POWER AMPLIFIER
- SOUTHDOWN CABINET

TOTAL **£55:13s.**

Stereo

- POINT-ONE STEREO PRE-AMPLIFIER
- STEREO 20 POWER AMPLIFIER
- SOUTHDOWN CABINET

TOTAL **£72:9s.**

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T.225: Miniature Slide Switch
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S.L.166: Very small low cost
mains neon indicator

T.280: Sensitive Snap Action Switch
Popular switch for tape recorders

T.626: Double pole 3-AMP switch
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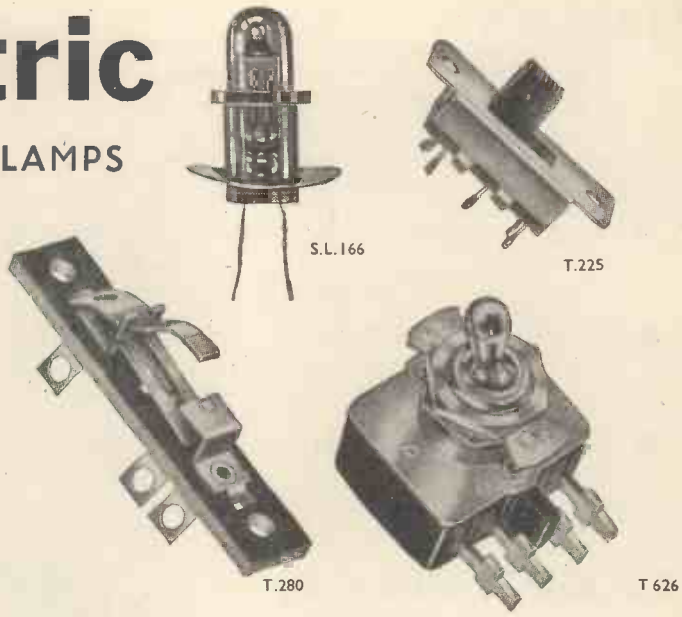

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BRITISH MANUFACTURED

Designed and built to rigid services specifications.

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Frequency Range: 85 to 1,000 megacycles.
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Frequency Range: 20 to 250 megacycles.
Frequency calibration accuracy: .002% at 25° C. (or .01% between −20° C. to +70° C.).

Crystal-controlled, portable heterodyne-type Frequency Meters used for Field testing and measurement of pulsed, modulated, or C.W.R.F. transmitters, receivers and signal-generators.

Mains Operated Power Unit available as optional extra and designed to fit into the battery compartment.
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Provisional specifications on a new wide-range, very high accuracy Frequency Meter and also an instrument covering the range 100 Kc/s to 1,000 Mc/s (higher under favourable conditions) available on request.

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Complete Specifications on application to:—

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SUMMER SALE

STOCK OFFERED AT SENSATIONAL REDUCTIONS THIS MONTH

Brayhead TV Turret Tuner, for 33/38 Mc/s. I.F., normally 79/6. Sale price 69/6, plus 3/6 post and ins.

Ditto, but for 16/19 Mc/s. I.F., normally 79/6. Sale price 69/6, plus 3/6 post and ins.

Output Transformer, fixed ratio for pentode, normally 6/6. Sale price 4/6, plus 1/-.

Valves, old types FC4-DDT4, etc. Sale price half current list price.

14in. TV Mask, grey plastic, normally 10/-. Sale price 7/6, plus 1/6 post and ins.

17in. TV Mask, grey plastic, normally 12/-. Sale price 9/-, plus 1/6 post and ins.

L2V 5 amp. Car Battery Charger, variable charge rate, in stove enamelled case, with meter, normally 85/-. Sale price 55/-, plus 4/6 post and ins.

250-0-250 60/80 mA. Mains Transformer, with 6.3 v. filament winding, half-shrouded dropthrough, standard replacement in many receivers, made to sell at 19/6. Sale price 12/6, plus 2/6 post and ins.

Ditto, but with additional 5 v. winding for separate rectifiers, made to sell at 21/-. Sale price 13/6, plus 2/6.

Transistor A.F. Transformer or driver, made to sell at 15/-. Sale price 8/6.

Sub-miniature electrolytic Condensers, for transistor sets: 1 mfd., 18 v.; 1.5 mfd., 6 v.; 2.5 mfd., 6 v.; 6 mfd., 6 v., 6 mfd., 6 v.; 5 mfd., 12½ v.; 8 mfd., 6 v.; 10 mfd., 6 v., 16 mfd., 12 v.; 25 mfd., 6 v.; 25 mfd., 25 v.; 30 mfd., 3 v. All normally 3/- each. Sale price 1/6.

Transistor Ferrite Rod Aerial, with medium and long wave coils with circuit, normally 12/6. Sale price 7/6.

Oscillator Coil and set of 3 I.F. transformers for transistor set, with circuit, normally 35/-. Sale price 23/6.

TV Rectifier, RM5 equivalent, normally 25/-. Sale price 12/6.

Auto Transformer, totally enclosed primary 200-250, secondary 110-120 v. 150 w. normally 27/6. Sale price 17/6.

I.F. Coils, standard size by Weymouth 465KC, dust cores, normally 12/6. Sale price 6/6 per pair.

Breakdown Unit. Over 20 lbs. of useful spares including metal rectifiers, transformers, pot meters, switches, valve holders, resistors, coils, coil formers, knobs, pye plugs, sockets, slow-motion drives, trimmers, etc., etc. Must have cost £100 each. Slightly soiled but most parts usable, 15/-, plus 7/6 carriage.

P.M. Speaker, 6½in. with output transformer. Normally 30/-. Sale price 17/6.

Miniature Microphones. Dynamic American. Beautifully made. Sale price 2/-.
Pilot Bulbs. 3-5 volt, 0.3 amp. 3/6 a box of 25.

Transistor Set Case with chrome handle, tuner knob and scale. Sale price 7/6.

14in. T.V. Cabinet, modern design. Cost £4 to make. Sale price 9/6, plus 3/6 carriage.

Stick Microphone, Cosmocord 39/1, normally £3/3/-. Sale Price 35/-.

Set of Four TV Parts, scan coils, line E.H.T. frame output and width control. Normally 57/6. Sale price 39/6, plus 2/6.

200 Service Sheets, for modern TV sets, normally 40/-. Sale price 30/-.

Windsor Cabinet and Chassis, comprises a veneered and polished cabinet, size 14 × 17 × 6½in., and prepared metal chassis with glass dial to fit, normally £3/15/-. Sale price 29/6, plus 5/-.

Charging Switchboard, offered at about 1/20th of original cost. Ex government, contains three reverse current relays, one voltmeter, one mains ammeter, two secondary ammeters and three variable resistors. In original cases. Sale price £3/15/0 1,250 watt, £2/15/- 550 watt, carriage 10/-.

Cine Camera, 16 mm. motorised (24 v. for 15 frames per second. Sale price £5/10/- plus 3/6 carriage.

Dinghy Mast, tubular aluminium, extends from 15in. to 9ft. Sale price 4/6, plus 1/6 p.

Insulated Terminal Heads, always useful, bargain at our normal price of 2/- dozen. Sale price 1/6 dozen, plus 1/- post.

Magneto Generator (hand), as used in telephones. Sale price 7/6, plus 1/6 postage.

This Month's Snip

Pocket Transistor Loudspeaker 3. A 2-transistor plus 1 crystal diode receiver for medium and long waves. Easy to carry about, as size only approx. 5in. × 4in. × 1in. All parts including cream plastic case, miniature loudspeaker. In fact everything needed down to last nut and bolt. Only 22/6, plus 1/6 p. & p. Batteries 10d. extra. Full constructional data included in above price or separately 1/6. Money refunded if not fully up to your expectations.

Remote Control Contactor, double pole, rated for 30 amps. D.C., suitable much higher current on A.C. Many applications, remote switching for motors, banks of lamps, etc. Probably cost £5 originally. Sale price 27/6, plus 3/6.

Push-Pull Transformers, input and output, midget, potted. Sale price 5/- pair, plus 1/6.

P.O. Type 3000 Relays, 2,000 ohm coil, 6 contacts 7/6, 4 contacts 6/6. 2 contacts 5/6, plus postage 1/-.

Variable Rheostats, heavy duty slider resistor rated at 25 amps., ideal for dimmer circuits, etc. Sale price 7/6, plus 6d. postage.

Versatile Wire, single strand 18 gauge, with p.v.c. covering. New ½-mile on drum. Sale price 6/6, plus 3/6 carriage.

Where the value of your order for small articles exceeds £2 these are post free. Under £2 add sufficient to cover and where carriage or postage specifically mentioned, add this in any case.

Wire Jointer (welder for 28 gauge or thinner), in bakelite case with trigger switch, works off step-down transformer. Sale price 2/6, plus 9d. postage.

B7G Holder, with skirt for screening can. Normally 10d. Sale price 6d. or 5/6 doz.

Phillips Trimmer, 0-30 pF. normally 1/9. Sale price 9d. or 7/6 dozen.

F.M. Tuner (Radio Constructor Circuit), normally £12/10/-. Sale price £6/19/6. Note: These are made up but may need attention. Plus 3/6 post and ins.

Metal Rectifiers, 250 v. 60-80 mA., ideal for mains set or instrument, or to replace that expensive valve. Sale price 3/6.

Rectifier Bargain, selenium rectifier 36 v. 9 amp., easily rebuilt into 6 full-wave charger rectifiers, suitable 6 or 12 v. battery at 3 amps. Sale price 15/-, plus 2/6 post.

Multi-speed Motor with gearbox, works on A.C./D.C. mains, gives any speed from 1 r.p.m. Sale price 17/6, plus 2/6 postage.

Navigation Compass, in carrying case but less fluid, may be slightly damaged. Sale price 5/9, plus 2/6 postage.

5 amp. 12 v. full-wave Charger Rectifier, normal price 17/6. Sale price 10/-, plus 1/6 post and ins.

Westinghouse Meters, 0-500 mA., 0-250 mA., 0-150 mA., 0-100 mA., 0-50 mA., D.C. 0-1.5 kv., 0-2.5 kv., 0-15 v. A.C. All 15/- each, plus 2/- postage.

Transistorised Stethoscope

Trace signal right through: radio, T.V., Tape amplifier, hi-fi, etc.—simplest way to fault find—carry it like a fountain pen—all parts including transistor, barrel crystal, everything except battery. 12/6 plus 1/6, battery 6d.—data included or separately 1/6.

Moving Coil Meter, 2½in. movement, 0-750 microAmp. Sale price 19/6. 0-30 mA., 15/-, plus 2/-.

Low Resistance Headphones, good British make. Sale price 6/-. Plus 1/6.

Chest Microphone, excellent American make, with adjustable mouthpiece, 6/6, plus 1/6.

Throat Microphone, excellent American make, 6/6, plus 1/6 post.

American Lightweight Headphones, Type H830. Sale price 17/6, plus 1/6 post.

Regulator Resistors, slider type, 11 ohm, 15/-, 3 ohm 12/6, 1 ohm, 2/6, plus 2/- post.

Converter 12, 24 v. D.C. Sale price 32/6.

E.H.T. Transformer, standard mains input, 3 secondaries, heavy duty potted transformer in cast case, normal price 20/-. Sale price 15/-, plus 3/6 post.

Suppressor Condenser, stops drills, etc. intefering with radio or television. Simple instructions included, normal price 1/6 each. Sale price 1/- each.

Bi-Metal Contact Strip for making thermostat, 1/9.

250 v. ½ amp. Rectifier, 7/6.

3-Phase Contactor, 17/6.

Filament Transformer, 6.3 v. 1½ amps., normally 8/6. Sale price 6/6, plus 1/-.post.

Filament Transformer, 6.3 v. 2 amp., normally 10/6. Sale price 8/6, plus 1/- post.
80 ohm Coax, low loss expanded polythene, normally 9d. per yard. Sale price 6d. yd.

Midget 3in. P.M. Loudspeaker, for transistor set. 3 ohm coil, normally 22/6. Sale price 15/-, plus 1/6 post.

Midget 208 pF. two-gang Tuning Condenser, for transistor set, normally 15/-. Sale price 9/-, plus 1/- post.

Push-Pull Output Transformer, for transistors OV72, etc., made to sell at 15/-. Sale price 8/6, plus 1/- post.

Connecting Wire, 24 gauge, tuned copper, P.V.C. insulated. Four 100 ft. coils, different colours. Sale price 8/-.

125 watt Choke for fluorescent tube, 22/-.

Superhet 7 v. 5 Waveband Chassis. Unused. Less valves and power pack. Slightly soiled 75/-. Coil pack with twice as much. Carriage and insurance 7/6.

Rectifier Unit, for working D.C. instruments, motorised equipment, etc., from A.C. mains. Input 200-240 v. Output 200/240 v. 300 m amp. 35/-, carriage 7/6.

Iron Dust Aerial Rod, 8 × 5/16in. dia., 2/6 each.

Westinghouse Rectifiers, type H4, 2/9 each.

Geiger Counter Tube, 20th Century. No. G25 with geiger counter. Sale price 27/6.

Twin-twisted Lighting Flex equivalent 1436, 12/6 per 100 yd. coil. Carriage 1/6.

3029 Twin T.R.S. 37/6 per 100 yd. coil. Carriage 8/6.

3029 Single T.R.S. 20/- per 100 yd. coil. Carriage 2/6.

Transistor A.F. equivalent to red spot. Sale price 4/6.
14in. TV Cabinet. Sale price 9/6. Carriage 3/6. Plywood worth more.

Pocket 6 Transistor Set Parcel, as recently advertised, 29/6. Sale price 22/6, with full instructions, or instructions only 1/6.

Sniperscope, "Cats Eye," for seeing in the dark Will work burglar alarms, counting circuits, etc. Sale price 4/-, plus 1/- post.

Telephone Handset, sound powered, just join two together with a pair of wires and you have telephonic communication. Sale price 25/-, plus 3/- post and ins

Ex R.N. Sound-powered Telephone, complete with sounder. Sale price 49/6 each.

12-24 v. D.C. Converter. Sale price 32/6.

R.F. 25 Tuner Unit, complete, new condition. Sale price 8/6 plus 2/6 post.

Stud Switch, heavy duty, 30 amp. contacts, for dimmer, charger, regulator, etc. Sale price 7/6.

0.0005 Twin Gang tuning condensers, 5/9, post free
Midget Coils (I.F.), dust cored, size 1½ × 1in., 465 Kc/s. 5/6 per doz.

Powerful Blower, with motor, 24 v., D.C., but can be operated off mains with rectifier. 15/-, post and packing 2/-.

200 watt Step Down Transformer, 230 v. to 125 v. or vice versa. 15/-, carriage 3/6.

Cathode Ray Tube, V.C.R. 517 replaces V.C.R. 97, 8/6 each, carriage 2/6.

10-core Flexible Cable, 230 v. insulation. Price 1/6 per yard.

7-core Flexible Cable, 230 v. insulation. Price 10d. per yard.

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post orders are dealt with from Eastbourne, so for prompt attention please post your orders to 66 Grove Road, Eastbourne, marked Department 2. Callers may use any one of the Companies below :

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266 London Road,
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Phone: CRO. 6558.
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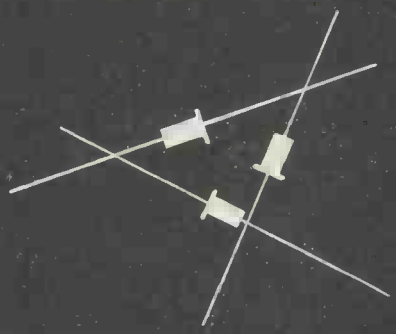

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0·75 AMP AT 25°C — 0·5 AMP AT 100°C

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"G" Series Rectifiers, which is the range from which these Type Approved devices have been developed, offer high temperature operation —250mA, at 150°C up to 600 P.I.V. —and high voltage operation up to 1000 P.I.V. **—and are available from stock**

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CV 7030	800v	8G7
CV 7029	600v	6G8
CV 7028	400v	4G8
CV 7027	200v	2G8
CV 7026	100v	1G8

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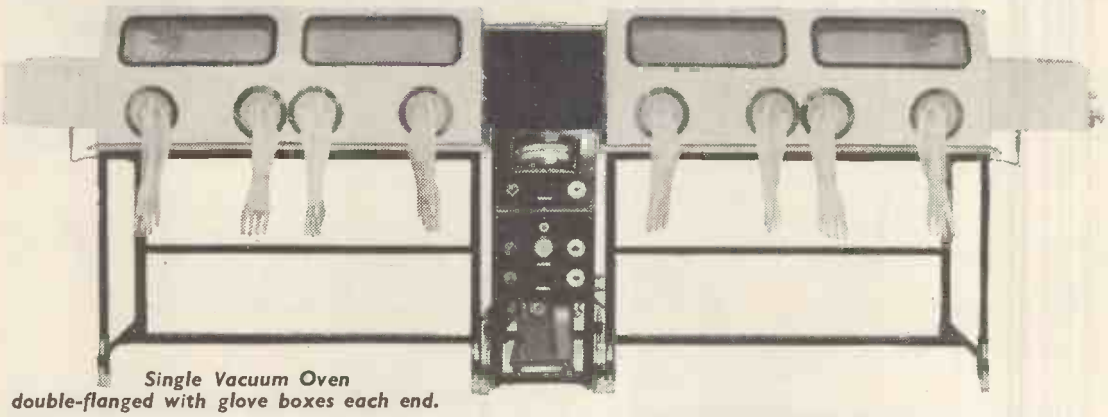
DOUBLE ENDED STAINLESS STEEL VACUUM OVENS



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- ★ Made throughout in polished stainless steel.
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- ★ Electrical interlocking of air inlet and isolation valves.
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- ★ Respective Vacuum Gauges incorporated.
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- ★ Flanged for fitting into Dry Box.

View showing automatic interlocking of unloading compartment on glove box.

Vacuum Oven with glove box.

We design and manufacture Ovens to Customers' special requirements. Should you have any problems in this field our Technical Department is always willing to help you solve them.

Vacuum Ovens with temperatures of up to 600°C are also manufactured by us on similar lines but with Sectional Heating and Water-Cooled Ends.

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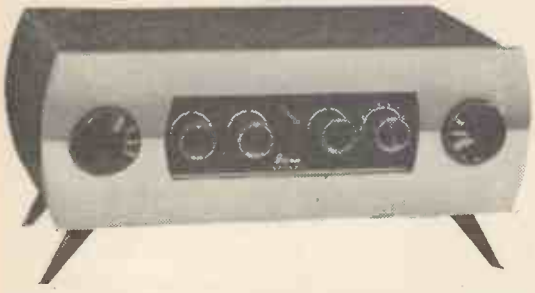
Chapman Stereo



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- ★ Distortion negligible all levels.
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305 Control Unit 18 gns. Main Amp. 20 gns. Matching FM or AM/FM Tuners available.

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10″ P.M. Unit, 16,000 gauss magnet. Die-cast chassis and universal impedance speech coil providing instantaneous matching at 3, 7·5 and 15 ohms. Handling capacity, 10 watts. Frequency response, 30 c.p.s. to 15,000 c.p.s.
Bass resonance, 35 c.p.s.

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The range of Stentorian loudspeakers incorporating the patented cambric cone was developed to provide reproduction that takes full advantage of the television and V.H.F. sound transmission and high fidelity recordings now available.

H.F. 1216 12″ full range Unit
This 12″ P.M. Unit fitted with a highly efficient magnet assembly having a flux density of 16,000 gauss on a 1½″ diameter pole.
Bass resonance 37 c.p.s.
Handling capacity 15 watts in bass reflex cabinet.
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Price £15

MODEL H.F. 1012
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Bass resonance 35 c.p.s.
Price £4.15.0 (inc. P.T.)

MODEL H.F. 816
8″ P.M. Unit, 16,000 gauss magnet. Fitted with cambric cone, die-cast chassis and universal impedance speech coil providing instantaneous matching at 3, 7·5 and 15 ohms.
Handling capacity 6 watts.
Frequency response, 50 c.p.s. to 15,000 c.p.s.
Bass resonance, 63 c.p.s.
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T. 10 Tweeter Unit
Speech coil impedance 15 ohms.
Response: 2,000/15,000 c.p.s.
Flux density: 14,000 gauss.
Power handling capacity: 5 watts.
Dispersion angle: 90°
Price £4.4.0

T. 12 Tweeter Unit
Price £12.12.0

T. 359 Cone Tweeter Unit
Frequency response: 3,000 c.p.s. to 15,000 c.p.s.
Overall size: 3½″ dia. × 2″ deep.
Voice coil impedance: 15 ohms or 5 ohms.
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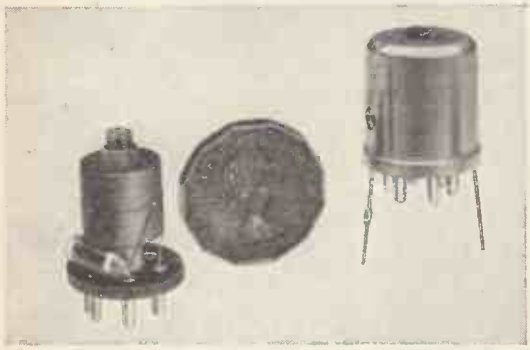

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- Preset output voltage from 2 to 18 volts.
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- Source impedance less than 0.02 ohms.
- High stabilization ratio 400—1.
- Small size 5 x $5\frac{1}{4}$ x 5in.
- Ripple 1 mV.

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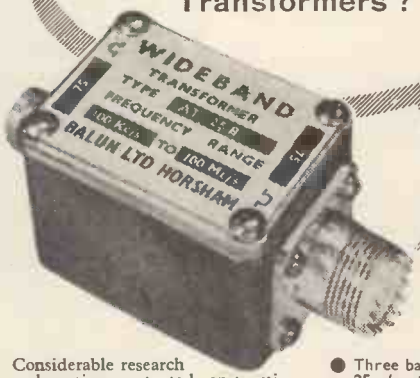

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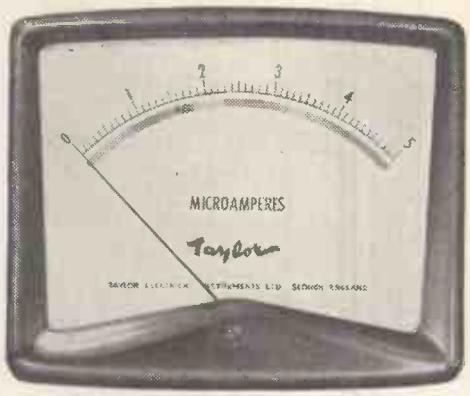

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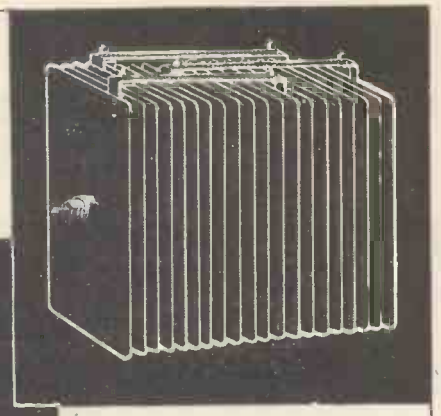
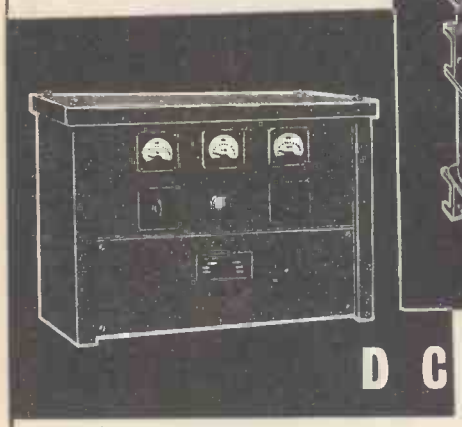


TRANSFORMERS



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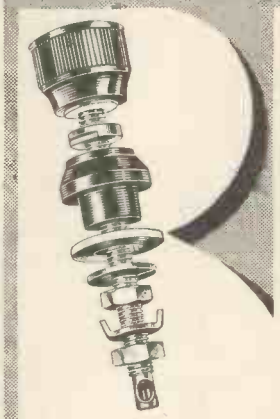

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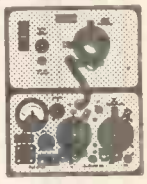

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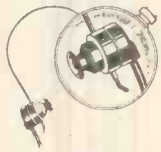

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ONLY **11 Gns.** Carr. 10/-. Or Factory built with 12 months' guarantee £13/19/6. TERMS ON ASSEMBLED UNITS. DEPOSIT 24/9 and 12 monthly payments of 24/9.

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For 200-250 v. 50 c.p.s. A.C. mains. Overall size only 11½ × 2½ × 2½in. Fitted Vol. and Tone Control with mains switch. Designed for use with any kind of single player or record changing unit. Output for 2-3 ohm speaker. Guaranteed 12 months. Only 59/6.

R.S.C. A7 3-4 WATT QUALITY AMPLIFIER. Spec. exactly as A5 below with exception of output voltage. Complete kit of parts, diagrams and instructions £3/15/-, carr. 3/6.

R.S.C. A5 4-5 WATT HIGH GAIN AMPLIFIER

A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high fidelity pick-up heads in addition to all other types of pick-ups and practically all makes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum-level is negligible being 71 D.B. down. 15 D.B. of negative feedback is used. H.T. of 300 v. 26 mA. and L.T. of 6.3 v. 1.5 a. is available for the supply of a Radio Feeder Unit or Tape Deck pre-amplifier. For A.C. mains input of 200-250 v. 50 c/s. Output for 2-3 ohm speaker. Chassis is not alive. Kit is complete in every detail and includes fully punched chassis (with baseplate) with the blue hammer finish, and point-to-point wiring diagrams and instructions. Exceptional value at only £4/15/- or assembled ready for use 25/- extra, plus 3/6 carriage. Or Deposit 22/- and five monthly payments of 22/- for assembled unit.

R.S.C. TRANSFORMERS.

Fully Guaranteed. Interleaved & impregnated. WE CAN QUOTE FOR SPECIAL OR STANDARD TYPES IN ANY QUANTITY. OUR FACTORY HAS SUPPLIED LEADING EQUIPMENT MANUFACTURERS AND GOVT. DEPTS. FOR 15 YEARS.

MAINS TRANSFORMERS. Primaries 200-230-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING.

250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a.	17/6
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	33/9
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t. 5 v. 3 a.	49/9

TOP SHROUDED DROP-THROUGH TYPE

260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	16/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
300-0-300 v. 130 mA., 6.3 v. 4 a., c.t., 6.3 v. 1 a., suitable for Mullard 510 Amplifier	29/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9

ELIMINATOR TRANSFORMERS.

120 v. 40 mA., 5-0-5 v. 1 a.	14/9
90 v. 15 mA., 6-0-6 v. 250 mA.	9/11

FILAMENT TRANSFORMERS

6.3 v. 1.5 a.	5/9	12 v. 1 a.	7/9
6.3 v. 2 a.	7/6	6.3 v. 3 a.	8/11
0-4-6.3 v. 2 a.	7/9	6.3 v. 6 a.	17/6

AUTO (Step Up/Step Down) TRANSFORMERS

50-80 watts 110-120 v./230-250 v.	11/9
150 watts 110-120 v./200-230-250 v.	27/9

OUTPUT TRANSFORMERS

Midget Battery Pentode 66:1 for 3S4, etc.	3/9
Small Pentode 5,000Ω to 3Ω	3/9
Standard Pentode 5,000Ω to 3Ω	5/9
Standard Pentode 8,000Ω to 3Ω	5/9
Push-pull 8 watts 6V6 to 3 ohms	8/9
Push-pull 8 watts EL84s to 15 ohms	8/9
Push-pull 10-12 watts 6V6 to 3Ω or 15Ω	16/9
Push-pull 10-12 watts to match 6V6 to 3-5-8 or 15Ω	17/9
Push-pull EL84 to 3 or 15 ohms	17/9
Push-pull Ultra Linear for Mullard 510	27/9
Push-pull 15-18 watts, sectionally wound, 6L6, KT66, etc., for 3 or 15 ohms	23/9
Push-pull 20 watt high-quality sectionally wound, 6L6, KT66, etc., to 3 or 15Ω	47/9

MICROPHONE TRANSFOMERS

120: 1 High quality, clamped	6/9
120:1 High quality Mu metal screened	8/9

SMOOTHING CHOKES

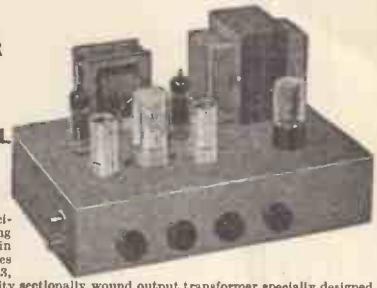
250 mA., 5 H., 100Ω	11/9	80 mA., 10 H., 350Ω	5/6
150 mA., 7-10 H., 250Ω	11/9	60 mA., 10 H., 400Ω	4/11
100 mA., 10 H., 200Ω	8/9	1 amp. 0.5Ω L.T. type	6/6

PARMEKO MAINS TRANSFORMERS. Fully shrouded.

450-0-450 v. 120 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9
500-0-500 v. 120 mA., 6.3 v. 4 a., 5 v. 3 a.	31/9

HIGH FIDELITY 12-14 WATT AMPLIFIER TYPE A11

PUSH-PULL ULTRA LINEAR OUTPUT "BUILT-IN" TONE CONTROL PRE-AMP STAGES



Two input sockets with associated controls allow mixing of "mike" and gram. as in A.10 High sensitivity. Includes 5 valves: ECC83, ECC83, EL84, EL84, 5V3. High Quality sectionally wound output transformer specially designed for Ultra Linear operation and reliable small condensers of current manufacture. INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut." Frequency response ± 3 D.B. 30-30,000 c/cs. Six negative feedback loops. Hum level 60 D.B. down, ONLY 23 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and microphones. Comparable with the very best designs. For STANDARD or LONG PLAYING RECORDS. For MUSICAL INSTRUMENTS such as STRING BASS, GUITARS, etc. OUTPUT SOCKET with plug provides 300 v. 30 mA. and 6.3 v. 1.5 a. For supply of a RADIO FEEDER UNIT. Size approx.: 12.9-7in. For A.C. mains 200-250 v. 60 c/cs. Output for 3 and 15 ohm speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied. (Or factory built 45/- extra). ONLY **8 Gns.** 10/-

If required louvred metal cover with 2 carrying handles can be supplied for 18/9. TERMS ON ASSEMBLED UNITS. DEPOSIT 18/9. and 12 monthly payments of 18/9. Send S.A.E. for illustrated leaflet detailing Ready-to-assemble Cabinets, Speakers, Microphones, etc., with cash and credit terms.

R.S.C. PORTABLE GUITAR AMPLIFIERS

JUNIOR 5 WATT. High Quality Output. Separate Bass and Treble "cut" and "boost" controls. Sensitivity 15 mv. High Flux 8in. l/speaker. Input sockets for Radio/Tape or Gram Pick-up and Mike /Instrument Pick-up. Handsome strongly made cabinet (size approx. 14 × 14 × 7in.). Finished in satin walnut and fitted carrying handle.

£8/19/6 Carr. 7/6. Or Deposit £1 and nine monthly payments £1.

Send S.A.E. for leaflet.

SENIOR 10 WATTS. High-Fidelity Push-Pull output. Separate Bass and Treble "cut" and "boost" controls. Twin separately controlled high gain inputs so that two instruments such as Guitar and String Bass can be used at the same time. Two Loudspeakers are incorporated, a 12in. P.M. for Bass notes, and 1 7 × 4in. elliptical for Treble. Cabinet is well made and finished satin walnut. Size approx. 18 × 18 × 8in. **15 Gns.** Plus 10/- carr. H.P. TERMS. DEPOSIT 26/9 and 12 monthly payments 26/9. Both models for 200-250 v. A.C. mains.

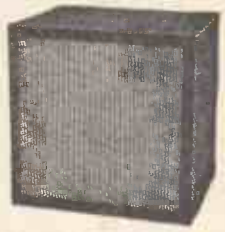
STAAR GALAXY 4-SPEED MIXER AUTO-CHANGERS. Brand New, cartoned. Turnover sapphire styli. Many exclusive features. Unique design motor virtually free from rumble For 200/250 v. A.C. mains. Limited number tested and guaranteed. £5/19/6. Carr. 4/6.

COLLARO CONQUEST 4-SPEED AUTO-CHANGERS. With studio pick-up with turnover head. Latest model for 200-250 v. A.C. mains, £6/19/6. Carr. 4/6.

B.S.R. MONARCH AUTO-CHANGERS. Type UA8, 4 speed T/O Pick-up with sapphire stylus £6/19/6. Carr. 4/6.

Any of above supplied with T/O stereo/monaural head for £1 extra.

COLLARO JUNIOR. 4-speed Single Players with Hi-Fi T/O crystal pick-up head. £3/19/6.

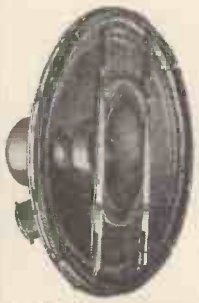


LOUDSPEAKER IN POLISHED WALNUT FINISHED CABINET. Gauss 12,000 lines. Speech coil 3 ohms or 15 ohms. Only £4/19/6. Carr. 5/-. TERMS: DEPOSIT 11/- and 9 monthly payments of 11/-.

12in. 20 WATT 15,000 line l/speakers 15 ohms in Cabinet finished as above. Size 18 × 18 × 8in. £7/19/6 or Deposit 13/10 and 12 monthly payments of 13/10.

ACOS HGP59 Hi-Fi Crystal Cartridges. (Turnover type with sapphire stylus). Standard replacement for Garrard and Collaro. Only 19/9. B.S.R. Ful-Fi 19/9. Garrard GC2 19/9. Acos Stereo/Monaural 49/9.

ACOS HIGH FIDELITY PICKUPS. GP54 with HGP59/52 Cartridge. Turnover sapphire styli, cream finish. Limited number at approx. half price. Only 29/11.



PLESSEY DUAL CONCENTRIC 12in. P.M. SPEAKERS

(15 ohms), consisting of a high quality 12in. speaker of orthodox design supporting a small elliptical speaker ready wired with choke and condensers to act as tweeter. This high fidelity unit is highly recommended for use with our A11 or any similar amplifier. Rating is 10 watts. Gauss 12,000 lines. Price only £5/17/6 Or Deposit 10/6 and 12 monthly payments of 10/6

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Oak and Wearite, synchronous 7-pin, 2 v. 7/9, 6 v. 8/3, 12 v. 4-pin non-synchronous 7/9.

EX-GOVT. MAINS TRANSFORMERS

All 200-250 v. 50 c/s. input.
Pr. 0-110-200-230-250 v., 275-0-275 v. 100 mA., 6.3 v. 7 a., 5 v. 3 a. 22/9
250 v. 60 mA., 6.3 v. 2 a. 10/11
300-0-300 v. 60 mA., 6.3 v. 2 a. 11/9
265-0-265 v. 150 mA., 6.3 v. 1 a., 5 v. 3 a., 5 v. 3 a. 29/11
350-0-350 v. 100 mA., 6.3 v. 2 a., 5 v. 2 a. 18/9
0-24-26-28 v. 15 amps. A.C. conservative Govt. rating (marked with D.C. rating after rectification) 69/9. Carr. 15/-.
0-10-20-25 v. 24 a. (Govt. rating) 79/6. Carr. 15/-.
AUTO 500 watts 0-215-220-225-230-235-240 v. .. 29/9
Carr. 7/6. 50 watts, 0-110/120-230/250 v. 8/11

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60 mA. 10 h. 400 ohms 2/11
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100 mA. 5 h. 100 ohms 3/11
100 mA. 10 h. 100 ohms 6/9
150 mA. 10 h. 100 ohms 10/11
120 mA. 12 h. 100 ohms 9/9
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250 mA. 5 h. 50 ohms 10/9

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6½ in. P.M. Speakers by leading manufacturers.

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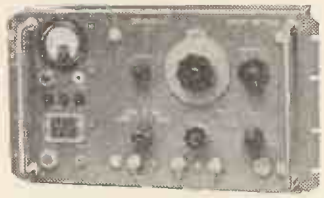
This offer will not be repeated.

EX-GOVT. CASES

Well ventilated, black crackle finished, undrilled cover. Size 14×10×8½in. high. IDEAL FOR BATTERY CHARGER OR INSTRUMENT CASE. COVER COULD BE USED FOR AMPLIFIER. Only 9/9, plus 2/9 post.

WAYNE KERR SIGNAL GENERATORS, TYPE CT53



8·9 to 300 megacycles. Output 1 micro-volt to 10 millivolts. Five position switched attenuator. Variable multiplier 1 to 10, calibrated 0-20 db. C.W. square wave and sine wave outputs. Complete with all valves, and charts.
SUITABLE FOR ALIGNING T.V. and V.H.F. RADIO For 200-250 v. A.C. mains. Beautifully made to very high standards. Worth over £100. Very limited number available at only **12** Carr. 15/- GNS.

MICRO-AMMETERS

500 Micro-amp. Scaled in Decibels. Diameter 3½in. Flush mounting 59/6
250-0-250 Micro-amp. Diameter 2in. 14/9
0-50 micro-amp. Diameter 2½in. approx. Scaled 0-100. Flush mounting 39/6

VOLTMETERS

0-300 v. A.C., 50 c.p.s. Diameter 2½in. approx. M.I. Only 16/9

MULTI-METERS

Ferranti, Universal (A.C. and D.C.). Complete in carrying case with leads 59/6

2. v. 16 A.H. EX-GOVT. ACCUMULATORS

New Boxed. Only 5/6 each, 3 for 15/-, plus 3/6 carr.

V.H.F./F.M. A.M. 4 WAVEBAND RADIO RECEIVERS

Complete in beautiful veneered Walnut Cabinet. Covers normal Short, Medium, and Long wavebands, plus V.H.F. Brand new and covered by usual 12 months' guarantee. For 200-250 v. 50 c.p.s. A.C. mains. **12½** Carr. 10/- GNS.

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Operates with two 4.5 v. Dry batteries which last for months under normal conditions. Plays 45 r.p.m. records at ample output level. Ideal for picnics, etc. Attractive two-tone Rexine covered cabinet. Limited number. Brand new, guaranteed, at only half list price. **9** Carr. 5/6 GNS.

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Miniature Moving Coil Differential Type. Single pole 2 way, or centre stable. Two coils each 350 ohms. Minimum operating current 140 micro-amps, nominal 400 micro amps, maximum 8 milli-amps. Two-way contact current 100 m.a. at 50v. A.C. or D.C. Size approx. 1½×⅞×⅞in. 19/6

Miniature type G.E.C. 670 2 MZB H/D M. 1095 .... 7/11

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2X2 .. 4/6	6F13 .. 11/6	10C2 26/6	27SU 19/11	CY31 16/7	EC54 6/-	EL33 12/6	KTZ63 7/6	10/6	UBC81 11/4	X61 .. 12/6	OC66 25/-
3A4 .. 6/-	6F23 10/6	10F1 26/6	28D7 .. 7/-	D1 .. 3/-	EC70 12/6	EL34 15/-	L63 .. 6/-	R12 .. 9/-	UBF80 9/-	X63 .. 9/-	OC70 14/-
3A5 .. 10/6	6F33 .. 7/6	10F9 .. 10/6	30C1 .. 8/-	D15 .. 10/6	EC92 13/3	EL38 26/6	MU14 8/-	R18 .. 14/-	UBF89 9/6	X65 .. 12/6	OC71 14/-
3B7 .. 12/6	6G6 .. 6/6	10LD3 8/6	30F5 7/-	D43 .. 17/3	ECC31 15/-	EL41 9/-	MX40 15/-	R19 .. 19/11	UBL21 23/3	X66 .. 12/6	OC72 17/-
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3Q4 .. 7/6	6J5G .. 5/-	15/11	30L1 .. 8/-	DAF91 6/-	ECC33 8/6	EL81 12/6	N78 19/11	SP41 .. 3/6	UCC85 9/-	X78 .. 21/3	OC75 20/-
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3S4 .. 7/-	6J7G .. 6/-	10P14 19/3	30P16 .. 7/6	DD41 13/11	ECC35 8/6	EL85 13/11	N308 20/7	SU25 .. 26/6	UCH42 9/6	XD(1.5) 6/6	OC78 17/-
3V4 .. 7/6	6K6GT 8/-	12A6 5/-	30PL1 17/6	DF66 15/-	ECC81 6/-	EL91 5/-	N339 15/-	SU61 9/-	UCH81 9/6	XFG1 18/-	OC81 18/-
5R4GY 17/6	6K7G 5/-	12AC6 15/3	35A5 21/3	DF70 15/-	ECC82 6/6	EL95 10/6	PABC80	T41 .. 23/3	UCL82 11/6	XFY12 9/6	OC170 35/-
5U4G 6/6	6K8G 6/6	12AD6 17/3	35L6GT 9/6	DF91 4/6	ECC83 7/6	EM34 9/6	13/11	TDD4 12/6	UCL83 19/3	XFY34 17/6	OC200 54/-
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5Y3GT 6/6	6L1 .. 23/3	12AH8 12/6	35Z3 10/6	DF97 .. 9/-	ECC85 8/6	EM80 9/-	PCC85 9/6	TP25 15/-	UF42 12/6	Y63 .. 7/6	XA101 23/-
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5Z4G 9/-	6L7GT 7/6	12AT7 6/-	35Z5GT 9/-	DH76 5/-	ECF80 10/6	EM84 10/6	PCC89 11/6	U12/14 8/6	UF85 9/-	Z66 .. 17/6	XA103 15/-
6A8G 9/-	6L18 13/-	12AU6 23/3	43 .... 10/-	DH77 7/-	ECF82 10/6	EN31 37/-	PCF80 8/-	U16 .. 10/-	UF86 17/11	Z77 4/6	XA104 18/-
6AB8 9/-	6L19 23/3	12AU7 6/6	50C5 12/6	DK40 21/3	ECH21 23/3	EY51 9/-	PCF82 10/6	U18/20 8/6	UF89 9/-		XB102 10/-
6AC7 4/-	6LD20 15/11	12AV6 12/8	50CD6G	DK91 6/6	ECH35 9/6	EY83 16/7	PCL82 10/-	U19 .. 36/-	UL41 9/-	Transistors	XB103 14/-
6AG5 5/6	6N7 .. 8/-	12AX7 7/6	36/6	DK92 9/-	ECH42 9/-	EY86 9/-	PCL83 11/6	U22 .. 8/-	UL44 26/6	and Diodes	XB104 10/-
6AK5 8/-	6P25 12/6	12BA6 8/-	50L6GT 9/6	DK96 8/6	ECH81 9/-	EZ40 7/-	PCL84 12/6	U34 .. 29/10	UL46 14/6	CG1C 4/-	XC101 16/-
6AL5 4/-	6P28 26/6	12BE6 9/-	53KU 19/11	DL66 15/-	ECH83	EZ41 7/-	PEN45 19/6	U25 17/11	UL84 8/6	CG4E 4/-	
6AM6 4/6	6Q7G 6/6	12BH7 21/3	72 .... 4/6	DL68 15/-	13/11	EZ80 7/-	PEN46 7/6	U26 .. 10/-	UM4 17/3	CG6E 4/-	New
6AQ5 7/6	6R7G 10/-	12J7GT 9/6	78 .... 6/6	DL92 7/-	ECL80 9/-	EZ81 7/-	PEN383	U31 .. 9/6	UM80 15/3	CG10E 4/-	Surplus
6AT6 7/-	6SA7GT 8/6	12K5 17/11	80 .... 9/-	DL94 7/6	ECL82 10/6	FC4 15/-	23/3	U33 .. 26/6	URIO 9/-	CG12E 4/-	Transistors
6AU6 10/-	6SL7GT 6/6	12K7GT 5/6	83 .... 15/-	DL96 8/6	ECL83 19/3	GZ30 9/-	PL33 19/3	U35 .. 26/6	UU8 26/6	GET103 12/6	H.F. 5/-
6AV6 12/8	6SN7GT 5/6	12K8GT 14/-	83V .. 12/6	DL810 10/6	EF22 14/-	GZ32 10/-	PL36 12/-	U37 .. 26/6		GEX33 4/-	L.F. 5/-

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Basically the unit is a back-to-back mounted, oil submerged, variable displacement hydraulic pump (input shaft) feeding a reversible hydraulic motor (output shaft) so that variation of the pump displacement by manual control gives very fine selection of output speed from zero up to 6% below input speed while a changeover valve in the supply lines to the motor provides instantaneous reverse at any speed. Recommended input speed 500-1,000 r.p.m., maximum power 1½ h.p. Both shafts ⅝in. dia. with Woodruff key.
Tested and fully guaranteed, supplied complete with technical data and performance curves for the remarkable price of £16 only, carriage paid.

REMOTE VIEWING UNIT APS4.

Attractive modern American black crackle case housing a fully mu-metal shielded 3in. CRT and two 6J6 B7G miniature valves with all leads contained in a protective 3-foot flexible hose terminating in a large multi socket. Miniature potentiometer is cable driven from knob by front face. Oblong aperture with tinted screen and graticule. Ideal for convenient positioning of monitor screen when bench space is limited. 2 FP7 CRT (Long Persistance green-yellow trace, 6.3 v. heaters) and valves worth the price. 25/- carriage paid.

BIAS RELAY POWER PACK for £1:

Admiralty Type 107 Rectifier Unit in totally enclosed rack mounting case. A.C. input 100, 110, 200, 210 up to 250 volts. D.C. output +50/0/—50 V. and 20 V. A.C. for pilot light. Spare A.C. outlets 80-0-80. Twin 9 Henry smoothing chokes and twin 8 uf paper capacitors with 15 k. bleeders. Two 500 mA. mains fuses and three 250 mA. output fuses. Full wave metal rectifier. Circuit diagram inside case. Size 19in. long by 3½in. high. Neat solid job, ready made to fit and forget. £1 carriage paid.

£10 GEIGER COUNTER

Circuit embodies U.K.A.E.A. patent. Specially moulded case. Currently being supplied throughout the world.
Three ranges—highly sensitive—light — portable — visual and audible response — plus output socket.
Ideal for introduction to radiation measurement and nucleonic circuitry. Specially written 40-page instruction manual supplied. Batteries £2/15/3 extra.

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Identical Parts. Guaranteed Performance.
Manual and printed circuit plates for battery pack supplied (assembled pack £2/15/3 extra). Fully illustrated assembly instructions. Spares and Service permanently available.

SELENIUM RECTIFIERS. 16/- post paid.
New, full wave, 12 volt, 4 amp. 4½in. dia. Type B.56.

MAINS OPERATED PHONE BELLS. 33/6 post paid.
New, weather protected, sealed twin 500 ohm solenoids driving striker between twin 6in. dia. plated gongs.

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Type 244 in neat black case 3 × 6 × 7½in. with flying lead 6 v. input and type 10H socket outlet. Mallory vibrator, metal rectifier, choke smoothed.

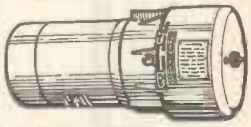
NICKEL CADMIUM BATTERIES. £6 carr. paid.
Five heavy duty 1.2 v. cells gives 6 v. for 75 amp.-hours. Fully charged in 15½ × 12 × 6in. wooden crate.

TORCH IGNITER PUMP. £2 carriage paid.

Plessey FP3 Mk. 4, totally enclosed, flame proof, compound wound motor driving a self-lubricating, positive displacement, sliding blade Kerosene pump through a 4 to 1 reduction gearbox. Running on 24 volts D.C. (designed for 16-29 v.) the motor develops 1/6th h.p. at 13,000 r.p.m., pumping about a gallon a minute at 30 p.s.i. (adjustable by pressure relief valve). Performance marginally less on 12 volts. Inlet and outlet unions. ¼in. B.S.P. Brand new.

200 AMPERE D.C. GENERATORS. £6 carr. paid.
Normally driven from tractor power take-off or the like to give a 29 v. output sufficient to weld ½in. plate.

AMERICAN COWL GILL MOTORS.



Smaller and neater than British counterpart. Split-field, reversible. 12-24 volts.
£2 carr. paid.

AMERICAN 400 CYCLES INVERTER.
30/- post paid
Very neat unit indeed, only 2¼ dia. by 4in. long on 1½in. high pedestal base containing suppressor. Ball bearings. 24 volt D.C., input for 26 volt single phase output. Instrument quality — as used with Bendix Magnesyn compass system.

1-30-A SIGNAL GENERATOR 100-156 Mc/s. Modern, portable, battery operated, 5-valve Signal Generator with alternative crystal or master oscillator, either optionally modulated by 1,000 c/s Hartley oscillator. Large directly calibrated dial with precision slow motion drive. Five step and variable attenuator. Supplied with matching black crackle carrying case for 6 and 135 v. batteries with 10ft. supply cable, and metal cased 1 mA. test meter for checking crystal resonance, etc. BRAND NEW, £2/17/6 *Plus 7/6 packing and carriage.*

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BRAND NEW, £4/2/6 *Plus 5/- packing and carriage.*

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UNIVERSAL AVOMETER MODEL "D"

D.C. VOLTS	A.C. VOLTS	D.C. Current	A.C. Current
150 mv.	7.5 v.	15 ma.	75 ma.
300 mv.	15 v.	30 ma.	150 ma.
1.5 v.	75 v.	150 ma.	750 ma.
3 v.	150 v.	300 ma.	1.5 amp.
15 v.	300 v.	1.5 amp.	7.5 amp.
30 v.	600 v.	3 amp.	15 amp.
150 v.	750 v.	15 amp.	Resistance
300 v.	1,500 v.	30 amp.	1,000Ω
750 v.			10,000Ω
1,500 v.			

Supplied reconditioned as new, with internal battery, instructions and leads £8/19/6 each. P/P. 3/6.

WESTON MODEL 772 TESTMETER

A.C. VOLTS	D.C. CURRENT	A.C. CURRENT
2.5 v.	100 micro/a.	500 ma.
10 v.	1 ma.	1 amp.
50 v.	10 ma.	5 amp.
250 v.	50 ma.	RESISTANCE
1,000 v.	100 ma.	100 ohms
D.C. VOLTS	500 ma.	1,000 ohms
2.5 v.	OUTPUT METER	100k. ohms
10 v.		10 megohms
50 v.		
250 v.		
1,000 v.		

Supplied in perfect working order complete with internal batteries. £7/10/-. P/P. 4/-.

BRAND NEW RCA EXTENSION LOUDSPEAKERS

8in., 3 ohm Quality Speaker mounted in attractive black crackle case to match AR88 Receivers, etc.

45/- each. P/P 3/6.

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Ranges 1.5, 3, 7, 15, 30, 60, 300 and 450 amps. 8in. mirror scale. Meter housed in polished teak case. Supplied complete with all shunts and leather carrying case. £15 each. P/P. 7/6.

FIELD TELEPHONES TYPE F. Generator

bell ringing. Supplied complete with batteries fully tested and complete with wooden carrying case 59/6 each. P/P. 3/6. 5/- pr.

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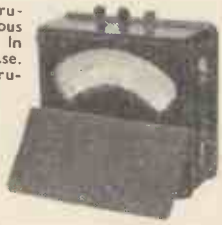

Brand new instruments by famous manufacturer. In polished teak case. Moving iron instrument reading A.C. or D.C. volts on 2 ranges 0-160 v. or 0-320 v., 8in. mirror scale. Accuracy within 2%. £5/19/6 ea. P.P. 3/6.

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50 microamp D.C. M/C. proj. rd. 2½in.	49/6
100 microamp D C M/C flush rd 3½in	62/6
500/0/500 microamp D C M/C proj rd 2½in	19/6
1 milliamp D C M/C flush sq 2in	22/6
1 milliamp D C M/C flush rd 2½in	25/-
1 milliamp D C M/C flush rd 3½in	50/-
1 milliamp D C M/C flush sq 4in	69/6
200 milliamp D C. M/C. flush rd. 2½in.	9/6
15 amp. D.C. M/C. Proj. rd. 2"	8/6
30 amp. D.C. M/C. flush rd. 2½in.	9/6
15 volt D.C. M/C. flush rd. 1½in.	10/6
120 volt D.C. M/C. flush rd. 3½in.	32/6
300 volt A.C. M/I. flush rd. 2½in.	25/-
300 volt A.C. M/C. rect. flush rd. 2½in.	25/-
500 volt A.C. M/I. flush rd. 2½in.	25/-

DON Mk. 5 FIELD TELEPHONES

Ideal for all inter-communication. Buzzer calling. Supplied fully tested, complete with batteries and instructions. 39/6 each, P/P. 3/6 ea., 5/- pr.

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Brand new, fully guaranteed, 3 speeds, 1⅞, 3¾, 7½, 3 motors, digital counter etc. 200/250v. A.C. operation. Supplied complete with 7in. spool, instructions and fixings. Only £12/19/6 each. P/P. 5/-. Tape not supplied.

RCA PLATE TRANSFORMERS

Input 200/250 volts. Output 2,000/0/2,000 volts 500 mA. tapped 1,500/0/1,500 volts. Supplied brand new boxed, £6/10/- each. carriage 10/-.

BRAND NEW MEDRESCO HEARING AIDS

Fully tested, complete with earpiece, all necessary leads and battery pouch. Incorporates three sub-miniature valves and sensitive crystal microphone. Price only 32/6 each, plus 1/- P. & P. Batteries 5/- extra.

MARCONI TYPE TF340 OUTPUT POWER METERS

Meter calibration 50 MW/17DB F.S.D. Meter multipliers, 0.1-1-10-100. Impedance values, 25-30-40-50-60-80-100-125-150-200 ohms. Impedance multipliers. 0.1-1-10-100. Perfect condition. £9/19/6 each, 7/6 carriage.

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Generator bell ringing. Light and very portable. Ideal for all installations. Supplied complete with batteries, fully tested. As new, 59/6 each. P/P. 3/-. 5/- pr.

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Input 230 v. 50 c/s. Output 620/550/375/0/375/550/620 volts 250 mA. Also 2-5 v 3 amp. windings Size 6¾ x 6¼ x 5½in. Brand new only, 45/- each. P/P. 5/-.

COSSOR 339
DOUBLE BEAM OSCILLOSCOPES

Operation 110/200/250 volts A.C. Ten position time base, 6 cps. to 250,000 cps. Amplifier 10 cps. to 2,000,000 cps. Perfect working order,

ONLY £15 EACH

Carriage 10/–.

G.E.C. SELECTEST MULTI-RANGE TESTMETERS

D.C. Volts	A.C. Volts	D.C. Current	A.C. Current
150 mv.	7.5 v.	15 ma.	75 ma.
300 mv.	15 v.	30 ma.	150 ma.
1.5 v.	75 v.	150 ma.	750 ma.
3 v.	150 v.	300 ma.	1.5 amp.
15 v.	300 v.	1.5 amp.	7.5 amp.
30 v.	600 v.	3 amp.	15 amp.
150 v.	750 v.	15 amp.	Resistance
300 v.	1,500 v.	30 amp.	1 K. ohm
750 v.			10 K. ohm
1,500 v.			

Incorporated overload trip and special safety interlocking switches. Supplied in perfect condition with leads and battery at £7/10/- each. P/P. 3/6.

MARCONI TF410C VIDEO OSCILLATORS. Ranges 20 cps. to 30,000 cps. and 30 kc/s. to 5 Mc/s. Variable attenuator. 200/250 v. A.C. Reconditioned, perfect order, £35 each.

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PADDED MOVING COIL HEADPHONES Good quality. complete with moving coil hand mike. Brand new. 12/6 per set. P. & P. 2/–.

PHOTO VOLTAGE AMPLIFIERS. These special units contain a 1 microamp. Tinsley mirror galvo and a double selenium photo cell. Brand new, £9/19/6 each. P/P. 7/6.

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MARCONI TF-428 B/I. VALVE VOLTMETERS. 5 ranges A.C. and D.C. 1.5, 5, 15, 50 and 150 volts. Complete with internal H.F. probe. Operation 200/250 volts A.C. Brand new, £17/10/- each. P/P. 10/–.

AMERICAN SUPER LIGHTWEIGHT HEADSETS. Res. 50 ohms. Brand new, 15/–. P/P. 1/6.

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750 WATT AUTO TRANSFORMERS. Tapped from 110 to 230 volts. Fine heavy duty type, 69/6 each. P/P 5/–.

AR.88 WAVECHANGE SWITCH ASSEMBLY. Brand new with screens, 17/6 each. P/P. 2/6.

MARCONI TF-517 SIGNAL GENERATORS. 10-18 Mc/s; 33-58 Mc/s; 150-300 Mc/s. 200/250 v. A.C. operation. 65/– each. FOR CALLERS ONLY.

HIGH FIDELITY RECORDING TAPES.

P.V.C. Base. Brand new in makers' cartons, universal plastic spools. 5in. 600ft. Std. 12/–; 5¾in. 1200ft. L.P. 19/6; 7in. 1200ft. Std. 19/6; 7in. 1800ft. L.P. 29/–; P/P. 1/–, 2 or more reels post paid. Spare spools. 5¾in. 2/3; 7in. 3/6.

R.1155 RECEIVERS

Standard Model B with improved geared drive, perfect order, £8/19/6 each, 7/6 P/P. Trawler Band Model L or N, £12/19/6 each. P/P. 7/6. Combined Power Pack and Audio Output Stage suit either model, 85/– extra.

MINE DETECTORS No. 4a

Complete equipment comprises Search Head, Amplifier Headset, Control Box, Telescopic Rods for Search Head, Search Head Test Unit and Test Depth Measure and Haversack.

Operation is from a standard 60 v./1.5 v. combined dry battery. The unit will detect ferrous or non-ferrous metals to a depth of 24in. giving maximum signal but can be used at greater depths giving lower output. Ideal for tracing underground pipes or cables and any hidden metallic objects.

Complete equipment supplied brand new in original transit cases complete with circuit and operating instructions.

PRICE **99/6** EACH

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BC 221 HETERODYNE FREQUENCY METERS

125 kc/s to 20 mc/s

Complete with all valves, crystal, headset and instruction book, but less calibration charts. 100% condition.

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(17)	R.C. Super Transistor/Crystal Rec. (ditto)	£1 7 6	1/3	3d.
(18)	R.E.P. 1-valve Battery Receiver	£2 2 0	2/–	9d.
(19)	" CRY-BABY " ALARM (Baby Alarm)	£3 12 6	2/6	1/–
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(21)	MULLARD 510 as above plus input selector and spare power supplies	£11 10 0	3/6	2/6
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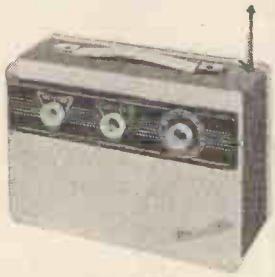
(34)	R.C. TRANSETTE 2-Transistor Personal Portable	£3 9 6	2/–	2/–
(35)	JASON EVEREST 6-Transistor 2-wave Portable	£13 19 9	3/6	3/6
(36)	JASON EVEREST 7-Transistor 2-wave Portable	£15 18 9	3/6	3/6
(37)	CLYNE Cathode Ray Oscilloscope	£12 19 6	5/–	10/–
(38)	Compact Multi-range Test Meter	£2 19 6	1/6	1/6
(39)	CAR RADIO, Printed Circuit, 5-valve S'het. **NEW LOW PRICE !**	£11 19 6	3/6	3/6
(40)	JASON Audio Generator AG10	£14 5 0	3/6	2/6
(41)	JASON Oscilloscope OG10	£22 10 0	5/–	3/6
(42)	Super SHORT WAVE RADIO, 1 valve	£1 15 0	2/–	2/–
(43)	" WAVEMASTER " 7-Transistor Luxury Portable	£10 19 6	3/6	2/6
(44)	" GOLD STAR " De-luxe 1-valve Portable	£1 17 6	2/6	1/6

Instruction Books which contain full description, easy-to-follow practical wiring diagrams theoretical diagrams, itemised price lists, etc., are free of charge with all parcels but may be purchased separately as shown above.

THE "WAVEMASTER" 7-TRANSISTOR LUXURY PORTABLE

400 MILLIWATTS OUTPUT



To build yourself Medium and Long Waves—Push-Pull Superhet A.V.C. Perfect Car Radio reception. Size 10in. × 6⅞in. × 4¼in. at base tapering to 4in. at top.

Very attractive two-tone grey Vynide covered cabinet with black and gold printed escutcheon plate, cream and gold knobs, handle and cabinet fittings. ★Weight—complete with long-life 7½ volt battery—4½ lb. ★Mazda High-grade transistors throughout. ★ High-Flux 7in. × 4in. Elliptical Speaker. ★ Slow motion tuning. ★ Co-axial socket at rear for direct connection to Car Radio Aerial. ★ Improved reception by use of seven-section plated telescopic aerial disappearing into Cabinet when closed, 34in. above Cabinet when fully extended.

Construction simplified by Bakelite chassis board with the following components already mounted:—I.F. Transformers (3). Oscillator Coil, Trimmer Bank, Output Transformer, Interstage Transformer, Aerial Brackets and Earth Bar. SPECIAL INCLUSIVE PRICE for all required components, full assembly instructions—nothing more to buy—is **£10/19/6 plus 3/6 P. & P.** Alignment service available. Full assembly instructions and individually priced parts list, all of which are available separately, 2/6, post free.

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HI-FI SHOWROOM
AT TOTTENHAM COURT ROAD FOR DEMONSTRATIONS OF THE LATEST
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BY ALL LEADING MANUFACTURERS

We stock equipment of Quality by all leading makers:
i.e., Leak, Quad, Armstrong, Dulci, Ferrograph, Reflectograph, Vortexion, Linear, Wharfedale, Grundig, Goodmans, W.B., Rogers, Garrard, Lenco, B.T.H., Pamphonic, Simon, Brenell, Collaro, Telefunken, Fi-Cord, etc., etc.
A full range of high quality cabinets to suit all purposes is on show, i.e., "RECORD HOUSING," "W.B.," "A.D.," etc. Enquire about our interesting part-exchange scheme for personal callers. H.P. Available.

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Readers will no doubt be pleased to know that our working model of this amazing organ for home construction, may now be heard and seen, at our Hi-Fi Showroom in Tottenham Court Road, W.1 For the benefit of constructors all components, keyboards, chokes, etc., are available ready made. Full constructional details are available in book form at 15/- plus 1/6 p. and p. We shall be happy to forward a complete price list on receipt of a stamp. Please address all organ enquiries for the attention of Mr. L. Roche.

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First delivery Famous American Ferrodynamics Acetate Base High Quality Recording Tape. An enthusiast's "must." Brand new (NOT SUB-STANDARD), 5in. 600ft. 16/-, 5in. 900ft. 18/6, 5¾in. 1,200ft. 23/6, 7in. 1,200ft. 25/-, 7in. 1,800ft. 35/-. Professional quality "MYLAR" Du Pont 5in. 1,200ft. 37/6. 7in. 1,800ft. 44/-. 7in. 2,400ft. 60/-, each on plastic spool. P. free.

DECCA PORTABLE AMPLIFIER. As supplied in famous DECCAMATIC III. Complete with small cream knobs. Full range tone and volume controls. Employs ECL82 valve. Size 3 x 3½ x 8¾in. Only 59/6 plus 2/6 P.&P
SPECIAL CELESTION 8 x 6in. elliptical high flux loudspeaker 30/- plus 1/- P. & P. to fit.
VERY ATTACTIVE PORTABLE CABINET in two-tone rexine covering for accommodating the above items and ancillary equipment. 75/- plus 5/- P. & P.
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A small three-valve **PORTABLE RECORD-PLAYER AMPLIFIER** mounted on baffle 12 x 7in., with High Flux 6½in. Loudspeaker. Valve line-up ECC83, EL84, EZ80. Incorporates separate bass and treble controls. Max. output 3 watts. Will match all types of high impedance pick-up. Ready to use, £5/12/6. P. & P. 3/6.
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TWO-TRANSISTOR PERSONAL PORTABLE. This is an amazing little receiver with built-in aerial, and small enough to be held in the palm of the hand. Medium wave reception at wonderful volume. Supplied with drilled chassis and colour coded components. Easily assembled with the aid of the easy-to-follow assembly instructions provided. Total cost of all necessary components, including transistors, Deaf-aid type earpiece, wiring wire and even solder. **ONLY 69/6** or complete with single standard High Resistance earphone at ONLY 62/6. Plus 1/6 P. & P. Parts price list and Easy Lay-out Plan s 2/- post free.

SUPER PERSONAL PORTABLE. A wonderful little set that you can take anywhere. Ideal for camping, picnics, etc. Detachable aerial rod supplied. Covers Medium waveband 200-500 metres. Can be built in approx. 1 hour. All necessary components available at the following SPECIAL INCLUSIVE PRICES: 1-valve version **ONLY 35/-**. Super 2-valve version **ONLY 41/-**. Plus 2/- P. & P. Send for point-to-point wiring diagram and parts price list 2/- post free. Extra for use with the above DLR5 balanced armature headphones, 7/6 pair.

CABY UNIVERSAL TEST METERS
These pocket-size multi-range test meters are of excellent quality and cover all the most useful ranges (A.C. Volts, D.C. Volts, resistance and current). Supplied complete with test prods, instruction book and batteries.
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JUST ARRIVED!
LATEST B.S.R. UA14. 4-speed. Attractive appearance. Wired for stereo. Fully guaranteed. £7/19/6, plus 3/6 P. & P.

B.S.R. UA8 STEREO/MONAURAL. Few only at £7/19/6, plus 3/6 P. & P. Brand new. Guaranteed.

No. 38 AFV WALKIE-TALKIE. A wonderful offer. This famous trans-receiver unit, with relay operated SEND/RECEIVE switch covering 7.4–9 Mc/s band, range approx. 5 miles. Good condition. ONLY 22/6 plus 2/6 P. & P. per unit (less accessories). Quantity export inquiries welcomed.

AERIAL TUNING UNIT ZA0841. This well made ex-W.D. unit contains a host of useful components including: 1 mA. 2in. flush round M/C meter, 1 mA. Westinghouse full-wave meter rectifier, 5-pole 5-way heavy-duty silver plated wavechange switch. 3in. dia. silver plated rotary tuning indicator, 350 pF tuning condenser with insulated coupler and 3½in. calibrated dial (0–180 deg.) etc., etc. Contained in strong metal carrying case 9in. x 9in. x 8in. with hinged lid. ONLY 27/6 plus 5/- C. & P.

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RED SPOT (Audio/Experimental Application) ..... 5/- ea.
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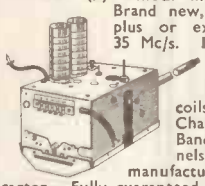
FRUSTRATED EXPORT Not repeatable! L., M. and S.W. SUPERHET RECEIVER. Manufactured by McCarthy for export. At present for operation on 6 volts, but conversion details supplied free.

Valve line-up: 6K8G, 6K7G, 6Q7C 6F6G, 6X5G and 6 volt 4-pin non-synchronous vibrator. 8in. P.M. Speaker, 4 watts output, P.U. socket Ext. L.S. socket, etc. Tone control. Fitted in polished wood cabinet, size 21¾in. x 10½in. x 10½in. These cabinets are slightly soiled owing to storage, but each is guaranteed unused, in serviceable condition, tested prior to despatch. Price £5/19/6 only plus P. & P. 7/6, plus 27/6 for A.C. Mains Conversion Components if required. **OUTSTANDING BUY!**

12 CHANNEL TV TURRET TUNER (By famous manufacturer). Brand new, **NOT** surplus or ex-equipment. 35 Mc/s. **I.F. PCC 84** and **PCF 80** valves. Complete with coils: Band I Channels 1 to 5. Band III Channels 8 to 11. In manufacturers original carton. Fully guaranteed at only 39/6 plus 2/6 P. & P.



AMPLIVOX HEADSET SPECIAL (not surplus). As used in up-to-date ships, aircraft, etc. Excellent quality super lightweight, low impedance, magnetic headphones complete with button microphone attached and plastic ear moulds. Absolutely brand new. 45/- pair. Plus 1/6 P. & P.

ACOS MIC 39-1. Crystal stick microphone. List price 5 gns. Our price 39/6 plus 1/6 P. & P.
MIC40. General purpose crystal microphone with desk stand. Our price 25/- only plus 1/6 P. & P.

LATEST COLLARO STUDIO TAPE TRANSCRIPTOR. 3 motors' 3 speeds, 1⅞, 3¾, 7½ i.p.s., takes 7in. spools. Push-button controls, £12/19/6 plus 5/- P. & P. Usual H.P. facilities.

TAPE RECORDER AMPLIFIER for use with Collaro Studio Transcriptor. Size 11¼ x 5 x 3in. Uses 3 valves, magic eye, contact cooled metal rectifier. Incorporates mike/gram/radio inputs, ext. l.s. jack, superimposing switch, £12/12/-. Complete with matching knobs (Gold/Black). Circuit etc. Post 3/6.

LATEST B.S.R. "MONARDECK." Single speed Tape Deck. Takes 5¾in. spools—3¾ i.p.s. At £9/19/6 only plus 5/- P. & P.

CLYNE RADIO LTD. THE COMPONENT SPECIALISTS
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LASKY'S RADIO

NEW TAPE RECORDER SCOOP

LASKY'S PRICE **29 GNS.**

including Acos mike and 1,200ft. Scotch tape. Carr. & Ins. 25/-.

A complete Tape Recorder using Collaro Studio 3-speed Deck, 1⅞, 3¾, 7½ i.p.s. Twin track, with pause control, rev. counter, latest type electronic recording indicator, superimposing switch, volume and tone controls, 7 × 4 loudspeaker, 4 watts output. Takes 7in. spools. In contemporary design carrying case, 9½ × 16 × 16in. Limited number. Brand new and unused.

Note: Can be used as a straight-through Amplifier.

NEW PRINTED CIRCUIT GRAM AMPLIFIER

Uses two valves, ECL82 and EZ80, and separate mains transformer to minimise hum. Incorporates Elac 8in. × 5in. loudspeaker with output transformer mounted. Concentric volume and tone controls. Size of printed circuit, 4 × 3 × 2¼in.

LASKY'S PRICE, complete, **69/6** Post 2/6.

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Smith's "Radiomobile" Converter offers short wave reception of your favourite stations. 6 or 12 v., positive or negative earth. Uses 6BE6 heptode freq. changer. Easily installed, may be used with any car radio. Chrome escutcheon, cream push buttons. Size: 1½ × 7 × 5in. All plugs and sockets included. Supplied with 3 removable coil units of your choice. Bandspread: 16, 19, 25, 31, 41, 49, 60, 90 metres.

LASKY'S PRICE **89/6** Post 2/6.

Additional Coil Units, 6/- each.

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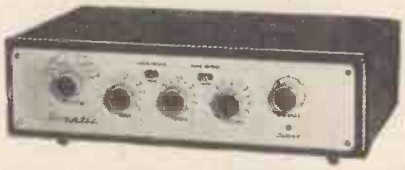
STEREOPHONIC HI-FI EQUIPMENT AT TREMENDOUS REDUCTIONS

For 100-250 v. A.C. mains. Brand new and unused in maker's cartons. Fully guaranteed. Limited quantities only. Come and have free demonstrations. Fullest details of any item post free on request.



SPA11 STEREO AMPLIFIER AND PRE-AMPLIFIER

Twin 10 watts output. 3-dimensional monaural reproduction by combining both channels. 3 inputs for each channel. Size: 14½in. wide, 4in. high, 8¾in. deep. LISTED AT £29/8/-.

LASKY'S PRICE **19 Gns.**

Carr. & Ins., 7/6.

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Twin 25 watts output. 6 inputs for each channel. Size: 14½in. wide, 4in. high, 14in. deep. LISTED AT £48/10/-.

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BM611. VHF-FM/MW-AM RADIO TUNER. Employs 8 valves plus rectifier. LISTED AT £40.

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DL7-35 POWER AMPLIFIER. 54 watts peak output. Freq. response 5 c/s-30 Kc/s ± 0dB. Two of these can be used in conjunction with SP21/2 Pre-Amp. Control Unit for stereophonic reproduction. Size: 14½in. long, 9in. wide, 8½in. high. LISTED AT £31/10/-.

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SP21/2. STEREO PRE-AMPLIFIER CONTROL UNIT. Twin channel. Designed primarily for use with two DL7-35 Power Amplifiers. Six inputs for each channel. Freq. response 40 c/s-15 Kc/s. LISTED AT £28/10/-.

LASKY'S PRICE **18 Gns.**

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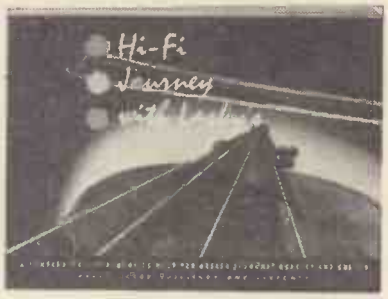

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Famous make. P.V.C. base on latest type plastic spools. Brand new, boxed and guaranteed.

1,800ft. on 7in. spool	32/6
1,200ft. on 7in. spool	21/-
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1,700ft. on 7in. spool	35/-
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Post: 1 spool 1/6. Orders over 60/- Rost free.

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3in.	5in.	5¾in.	7in.	8¾in.
2/9	3/6	3/3	3/6	5/6

7in. Metal Spools, 1/9 each

Post extra

TAPE RECORDER AMPLIFIER for use with Collaro Studio Transcriptor. Uses 3 valves, magic eye, contact cooled metal rectifier. Incorporates mike/gram/radio inputs, ext. Ls. jack, superimposing switch. Complete with gold/black knobs. **12 Gns.** Post 3/6.

ALL MAKES OF TAPE in stock. Long Play, Double Play, and the American "MYLAR."

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Carr. 21/-.

Latest **COLLARO STUDIO TAPE TRANSCRIPTOR.** 3 motors, 3 speeds. 1⅞, 3¾, 7½ i.p.s. Push-button controls.

Carr. 12/6. **14 Gns.**

FERGUSON F.M. TUNER

FM/1. Brand new and unused. Employs 3 valves and incorporates own power supply. Freq. range 87.6 to 100 Mc/s continuously. Metal case, hammer finish, size 10in. × 7¾in. × 2¾in., with smart escutcheon in cream.

LIST PRICE 18 Gns.

LASKY'S PRICE **£13/19/6**

Carr. & Ins. 2/6.

"LINEAR" AMPLIFIERS

Complete range of types in stock. Leaflets on request.

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4-SPEED MIXER AUTO-CHANGERS

Brand new in maker's cartons

B.S.R. UA12. Wired for STEREO, complete with stereo cartridge. Post 5/-. **£8.19.6**

B.S.R. Type UA8, complete with latest B.S.R. "ful-fi." Post 5/-. **£6.19.6**
Stereo version, £7/19/6.

COLLARO. Complete with Studio crystal p.u. and sapphire stylus. LIST £13/17/-.
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GARRARD

Model 121. Mk. II	£10 10 0
121, Mk. II STEREO	£11 10 0
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RC.88	£12 19 6
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LASKY'S CAR RADIO

CAN BE BUILT ABSOLUTELY COMPLETE

FOR £12.10.0
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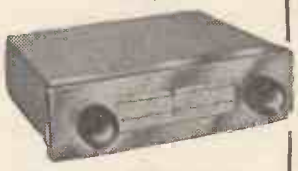

- ★ Small size. Will fit any car
- ★ 12 volt operation
- ★ New Hybrid circuit
- ★ Transistor output
- ★ New Type Brimar valves
- ★ No Vibrator, 12 volt H.T. & L.T
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- ★ Permeability tuning
- ★ 7in. × 4in. elliptical speaker.

Instruction Booklet giving full details, illustrations, dimensions, circuit diagram and shopping list 2/6 post free (returned if you order).

SINGLE PLAYERS

Brand new and unused

Auto start and stop. Complete with pick-up and crystal cartridge.
GARRARD 4SP **£6 19 6**
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COLLARO JUNIOR 4-speed motor and separate pick-up with cartridge styli **£3 15 0**
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ALL TYPES OF CHASSIS

We hold the largest selection of leading makes, including **ARMSTRONG, DULCI, EMPRESS,** etc.
A.M. chassis (l.,m.,s.) from **7 Gns.**
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A.M./F.M. STEREO from **22 Gns.**

BUILD THIS FINE 3-SPEED TRANSISTOR RECORD PLAYER

FOR **£9.19.6** Carr. 7/6

6 volt operation. For all L.P. and standard records. Complete parcel comprises:—

AMPLIFIER. 300 milliwatts output, using two OC71 and two OC72 transistors. Fully assembled. **79/6.** Knobs 3/6 extra.

LOUDSPEAKER. 30 ohms, 7×4in. elliptical Speaker matched to amplifier. **25/-.**

3-SPEED TURNTABLE with rubber mat and speed adjustment, complete with t.o. crystal cartridge and two sapphire styli. **79/6.**

CARRYING CASE as illustrated, handsome two-tone finish, size 17in. deep, 14in. wide, 5¾in. high. **49/6.**

Batteries extra. All components available separately. Build this modern Record Player for £££s less than an equivalent ready-built Player.

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The DIANA. A high quality moving coil microphone with unique magnetised table base. Response 30-15,000 c.p.s. Ideal for tape recorders. LIST 4 GNS.

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Desk Stand 1/6 extra

ACOS type 33/1. Crystal hand or table Mike, **29/6.** Post 1/6.

RIBBON MIKE on table stand. Famous make, high impedance.
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"ALFA" MULTI-RANGE. A.C. and D.C. 3,333 ohms per volt. Ohms ranges to 2 megs. Volts A.C. and D.C. up to 1,200. Overall size: 5¼ × 3⅝ × 1⅝.
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Post 2/-.

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NEW AND UNUSED

FERRANTI, 9in. type T9/3. 4 v. heater, triode, octal base, standard deflection. LIST 9 GNS.
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FERRANTI, 12in., types T12/44 and T12/54.
LIST £12. LASKY'S PRICE Carr. & Insur. 12/6. **59/6**

FERRANTI 17in. type TR17/10, 6.3 v. .3 amp. heater. Brand new and unused.
LASKY'S PRICE Carr. and Insur. 12/6. **£6.19.6**

17in. 90 degrees C.R. TUBES
Seconds but in perfect working order and guaranteed. **£4/19/6.**
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RE-GUNNED C.R. TUBES
GUARANTEED FOR 12 MONTHS

Type	Price	Carr. & Ins.
12in. round	£6 10 0	....12/6
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15in. & 16 round..	£6 19 6	....12/6
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12-CHANNEL TURRET TUNERS

Buy now free of Pur. Tax. Large selection, many by famous makers such as Cyldon, Brayhead, Plessey, Cossor, etc. all I.F.s. Brand new and unused. Write for quotation on model you require. Listed at 7 Gns.
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BUILD THE COSSOR "TRAVELLER'S FRIEND"

4-Transistor POCKET SUPERHET

Uses 9 v. PP4 battery Covers 190-550 metres. Output 30MW. All components including 4 transistors. OC44, OC45, OC45, OC72, two OA70 diodes, two AGC systems, 2½in. M.C. speaker, Ferrite slab aerial, etc., leatherette case, size 6 × 3¾ × 1¼in. Printed Circuit and easy-to-follow instructions.
LASKY'S PRICE Post 2/6 **£7.19.6**
Originally nearly £20
All components available separately.

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P.N.P. Junction Types

AUDIO, yellow/green spot, each 5/-.
R.F., yellow/red spot, each 7/6.
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THE TYPE "C" PREAMP. HF/TR3 AMPLIFIER and the HF/G2 UNITS are STERN'S—MULLARD DESIGNS

EACH RECORDER IS SUPPLIED COMPLETE WITH MICROPHONE and SPOOL OF TAPE

MODEL CR3/S

Incorporating the HF/TR3 AMPLIFIER and COLLARO "STUDIO" TAPE DECK. Twin track operates at 1⅞, 3¾ and 7½in./sec.

Price **£39.10.0**

H.P. Terms. Deposit £7/18/- and 12 months at £2/17/11.

MODEL HF/GR2

Contains the Model HF/G2A-D UNIT (described opposite). A small robust recorder with outstanding performance. Truly portable, weighs only 22 lbs. Twin Track operates on 3¾in./sec. speed.

Price **£29.15.0**

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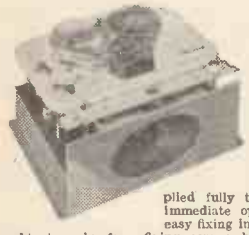
Incorporates the HF/TR3 AMPLIFIER and COLLARO Mk. IV "Transcriptor" Tape Deck. Upper and lower tape tracks operates at speeds 3¾, 7½ and 15in./sec.

Price **£47.10.0**

H.P. Terms. Deposit £9/10/- and 12 months at £3/9/8.



MODEL HF/G2A-D

A complete self-contained Tape Recorder chassis incorporating Loudspeaker and comprising the Model HF/G2A Amplifier connected to the Garrard Tape Deck. Operates at 3¾in./sec. speed and supplied fully tested and ready for immediate operation, designed for easy fixing into a portable case or cabinet, only four fixing screws being required.

Price **£25.0.0**

(Including a 4in. spool of Long Play Tape.)

HIRE PURCHASE TERMS: Deposit £5 and 12 monthly payments of £1/16/8.

Alternatively we offer—Complete Kit of Parts to build the HF/G2A Amplifier with the ASSEMBLED AND TESTED GARRARD TAPE DECK for **£22.0.0**

H.P. Deposit: £4/8/- and 12 months of £1/12/3.

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Incorporates the HF/TR3 AMPLIFIER and TRUVOX Mk. VI Tape Deck. Twin track operating at speeds 7½ & 15in./sec.

Price **£49.10.0**

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THE IDEAL "LINK" TO ADD FULL TAPE RECORDING FACILITIES TO HIGH QUALITY HOME INSTALLATIONS, RADIOGRAMS, etc. Comprises the HF/G2P Tape Pre-amplifier fitted to the Garrard Tape Deck, operates at 3¾in./sec. speed. connects into the tape input channel or pick-up sockets of existing amplifier or Radio Chassis.

COMPLETE WORKING UNIT, containing 4in. spool of Long Play Tape.

Price **£23.15.0**

Hire Purchase Terms: Deposit £4/15/- and 12 monthly payments of £1/14/10.

Alternatively we offer—Complete Kit of Parts to build the HF/G2P Pre-amplifier with the ASSEMBLED AND TESTED GARRARD DECK for **£20.15.0**

Deposit £4/3/- and 12 months at £1/10/5.

FOR THE HOME CONSTRUCTOR

SPECIAL "COMBINED ORDER" PRICES

(a) The COLLARO "STUDIO" TAPE DECK and our Mullard Type "C" PRE-AMPLIFIER and Power Unit assembled and tested **£29.10.0**
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(b) As above but Type "C" PRE-AMPLIFIER supplied as complete Kit of Parts..... **£26.10.0**

(c) The COLLARO Mk. IV TAPE DECK and the MULLARD Type "C" PRE-AMPLIFIER and Power Unit assembled and tested **£35.0.0**
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(c) COMPLETE KIT to build the HF/TR3 together with the Mk. IV COLLARO "TRANSCRIPTOR" DECK **£30.15.0**
(£1 extra if we are required to wire up Deck Banks)

(d) As above but HF/TR3 ASSEMBLED and TESTED..... **£34.10.0**
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(£1 extra is we are to wire up Deck Switch Banks)

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(f) As above but HF/TR3 ASSEMBLED and TESTED..... **£39.10.0**
H.P. Terms: Deposit £7/18/-, 12 months of £2/17/11.

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(h) As above but HF/TR3 ASSEMBLED and TESTED..... **£45.0.0**
H.P. Terms: Deposit £9, 12 months of £3/6/-.

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Attractive PORTABLE CASE is available to accommodate the TRUVOX or COLLARO TAPE DECKS and we offer it together with ROLA/CELESTION 10/ 6in. LOUDSPEAKER—ACOS CRYSTAL MICROPHONE—and 1,200ft. SPOOL E.M.I. TAPE—ALL FOR..... **£9.10.0**
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For use with the MULLARD 2-valve preamplifier with which an undistorted power output of up to 10 watts is obtained. We supply SPECIFIED COMPONENTS AND NEW MULLARD VALVES including PARMEKO MAINS TRANSFORMER and choice of the latest Ultra-linear PARMEKO or the PARTRIDGE Output Transformer.

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Alternatively we supply ASSEMBLED AND TESTED **£11.10.0**

ABOVE INCORPORATING PARTRIDGE OUTPUT TRANSFORMER £1/6/- extra.

MULLARD 2-VALVE PREAMPLIFIER-TONE CONTROL UNIT

Employs two Mullard EF86 valves and designed to operate with the Mullard "5-10" Main Amplifier but also suitable for all power Amplifiers requiring an input of up to 250 m/volts. Inputs for Crystal and Magnetic Pick-ups, Microphone, Tape. Separate Bass and Treble Controls.

KIT OF PARTS **£6.6.0** or ASSEMBLED **£8.0.0**

THESE TWO UNITS PURCHASED TOGETHER, ARE OFFERED FOR.....KIT OF PARTS .. £15/15/-, or ASSEMBLED .. £18/18/-

MULLARD "3-3" AMPLIFIER

Ideal for small high quality installation, provides excellent reproduction up to 3 watts output. Inputs for Crystal Pick-ups and Radio Tuner.

KIT OF PARTS ..... **£7.10.0** or ASSEMBLED **£8.19.6**

MULLARD "5-10" AMPLIFIER MODEL 510/RC

A complete Amplifier, incorporating CONTROL UNIT. Providing up to 10 watts high quality reproduction. Inputs for crystal pick-ups and Radio Tuner.

KIT OF PARTS ..... **£11.10.0** or ASSEMBLED **£13.10.0**

STEREO "3-3" MAIN AMPLIFIER

Comprises two MULLARD 3-3 Main Amplifiers on one chassis. Operates with MULLARD STEREO PREAMPLIFIER. Output power 6 watts. Inputs for Crystal Pick-Up and Radio Tuner.

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COMPLETE STEREO AMPLIFIER

Meets the many requests for a low priced but good quality Stereophonic Amplifier. Output power is 4 watts and suitable for Crystal Pick-Ups.

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MULLARD "STEREO" PREAMPLIFIER

Suitable for Stereo or Monaural operation with any Power-Amplifier requiring input of up to 250 m/volts. Inputs for Crystal or Magnetic Pick-ups, Microphone, Tape. Separate Bass and Treble Controls.

KIT OF PARTS ..... **£12.10.0** or ASSEMBLED **£15.0.0**

THIS STEREO PREAMPLIFIER IS OFFERED TOGETHER WITH . . .

(a) One "MULLARD" 5-10 MAIN AMPLIFIER
KIT OF PARTS ..... **£21.10.0** or ASSEMBLED **£25.0.0**

(b) Two MULLARD "5-10" MAIN AMPLIFIERS
KIT OF PARTS ..... **£31.0.0** or ASSEMBLED **£36.0.0**

(c) MULLARD "Stereo" 3-3 MAIN AMPLIFIER
KIT OF PARTS ..... **£21.10.0** or ASSEMBLED **£25.0.0**

TAPE AMPLIFIERS and PREAMPLIFIERS presented from MULLARD DESIGNS

MODEL HF/TR3 TAPE AMPLIFIER

(Mullard Type "A" design)

A very high-quality Amplifier incorporating 3-speed treble equalisation, using the latest FERROXCUBE POT CORE INDUCTOR. FOR COLLARO-TRUVOX-BRENELL-WEARITE or MOTEK Tape Decks, has GILSEN Output Transformer. Includes separate Power Supply Unit.

KIT OF PARTS ..... **£12.15.0** or ASSEMBLED **£16.10.0**

MODEL HF/G2P TAPE PREAMPLIFIER-ERASE UNIT

Identical to the HF/G2A but excludes Loudspeaker and output transformer. (See Model HF/G2P-D.)

KIT OF PARTS ..... **£9.10.0** or ASSEMBLED **£11.5.0**

Mk. II "Fidelity" FM TUNING UNIT

An attractively presented Unit incorporating MULLARD PERMEABILITY TUNING HEART and corresponding Mullard valve line up.

FOR THE CONSTRUCTOR .... **£10.10.0** or ASSEMBLED .. **£14.5.0**

SPECIAL CASH ONLY OFFER ! !

This very attractive PORTABLE AMPLIFIER CASE together with a good quality GRAM AMPLIFIER and a matched P.M. SPEAKER. ALL FOR ONLY **£8.7.6** (plus 7/6 carr. and ins.). The Amplifier consists of a 2-stage design incorporating the 3 modern BVA valves and has separate BASS and TREBLE CONTROLS. The Portable Case will also accommodate almost any make of Autochanger and is attractively finished in Grey Colour Rexine—WE ALSO SUPPLY SEPARATELY:—

(a) The 2-stage (plus Rectifier) AMPLIFIER £4 2 6

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(c) 6½in. P.M. SPEAKER 18 9

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Designed to operate through the Pick-up Sockets of the standard RADIO RECEIVER through which first-class results are obtained. It consists of a Twin Track Tape Deck, incorporating matched Preamplifier, and operates at 3¾in./sec. speed. Supplied fully tested and completely assembled on an attractive wood plinth, and only requires connections to the mains supply and the Pick-up Sockets, for which purposes "floating" leads are incorporated.

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MULLARD TYPE "C" TAPE-PREAMPLIFIER ERASE UNIT

The "Hi-Fi" link to add full tape recording facilities to High Fidelity home installations. Incorporates FERROXCUBE POT CORE PUSH-PULL OSCILLATOR and 3-speed treble equalisation by FERROXCUBE POT CORE INDUCTOR. FOR WEARITE—COLLARO—TRUVOX—BRENELL or MOTEK TAPE DECKS. Includes separate Power Supply Unit.

KIT OF PARTS ..... **£14.0.0** or ASSEMBLED **£17.0.0**

(Excluding Power Unit £11/15/- and £14/10/- respectively.)

MODEL HF/G2A TAPE AMPLIFIER

Completely self-contained and specifically designed to operate the GARRARD TAPE DECK. All input and output sockets, loudspeaker and Power Unit are contained on chassis which is constructed for direct attachment to Deck (see Model HF/G2A-D).

KIT OF PARTS ..... **£11.0.0** or ASSEMBLED **£12.15.0**

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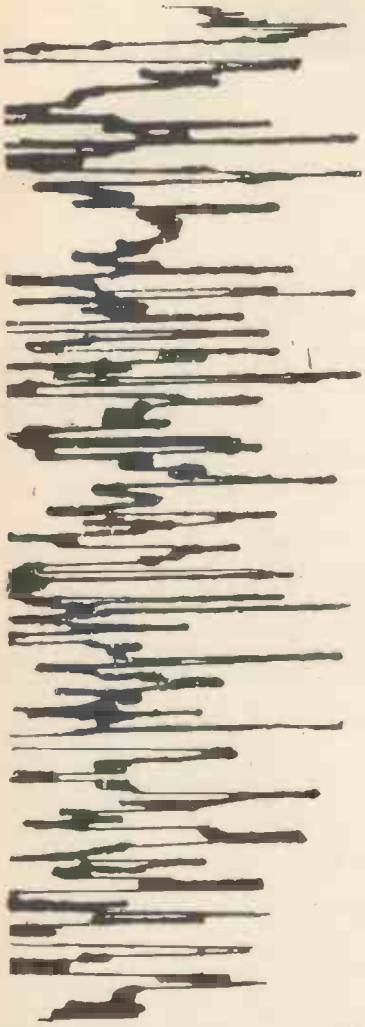
Proceedings of the Second International Conference Paris 1959



Medical Electronics

Edited by C. N. Smyth MA., B.SC.ENG., B.CH., MIEE

and published for the International Federation for Medical Electronics

Electronic techniques, are becoming increasingly important in the medical sphere, because they provide extremely sensitive and versatile means of measuring or examining physiological effects which often cannot be detected by other methods. The growing importance of medical electronics was first recognized on a world scale when the First International Conference was held in Paris in 1958. This was an exploratory meeting, which led to the organization of the full-scale Second International Conference on Medical Electronics, held at the UNESCO building in Paris in 1959. This book is a record of the proceedings.

Because the 1959 conference was the first of its kind, the door was deliberately held open for a wide variety of papers, so that the proceedings would give a true impression of the extremely broad scope of medical electronics. The choice of contributions for publication has been difficult; but in making the selection attention has been paid to the opinions of conference delegates and in particular the chairmen of the specialist sessions. Some papers were selected for publication in abstract form only, largely because they would be or had been printed more completely elsewhere. But, of the 160 papers delivered, as many as 150 are represented in this volume.

For convenience in publication the papers have been specially grouped in eight broad sections (not corresponding to the 16 sessions of the Conference itself). These are Electrophysiological Techniques; Electroencephalography; Cardiology; Manometry and Flow Measurement; Acoustic Techniques, Automation in Medicine; Radiology and Isotopes; Chemical Instrumentation. This classification draws together papers which are related by similar electronic techniques.

This book is primarily a record of useful and original ideas expressed at the Conference; it is a book in which to discover what work is being done, where, and by whom. It should prove to be a basis for scientific collaboration in an interesting and profitable field of research, and as such, a very valuable addition to the literature of medical electronics.

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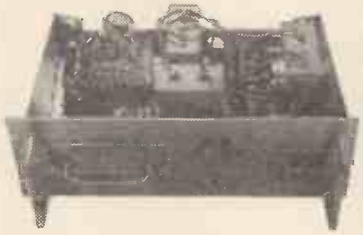

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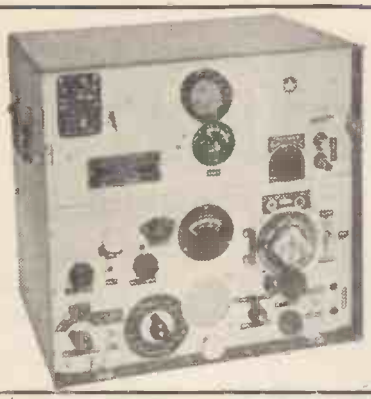

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Utilises 4 valves, 1 each 5Z4G, 6V6G, 6J7G, 6J5G and high quality components such as "O" Core Transformers and Block Paper Smoothing Condensers. A.C. Mains Pack for nominal 110 x 230 volts. Provision for 600 ohms or High Impedance Input. Output to 600 ohm Line. For normal use only requires changing Output Transformer. Output approximately 4 watts. Designed for Standard Rack Mounting, having grey front panel size 19in. x 7in. All connections to rear panel, front having "On/Off" Switch. Gain Control, Indicator Light. Fuses and Valves Inspection Panel. BRAND NEW IN MAKER'S PACKING. ONLY £4/9/6 (carriage 10/6).

EHT TRANSFORMERS. 7 kV (Rect.) with 2 v. 1 a., 89/6. 2.5 kV. (Rect.), with 2-0-2 v. 1.1 a., 2-0-2 v. 2a., (for VCR 97 tube etc.). 47/6 (postage 2/- per trans.).

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Manufactured by General Electric Co. and has exactly the same ranges as the Avometer D, but with a rather large mirror scale. Size 9in. x 7in. x 5in., with carrying strap. Thoroughly overhauled and in perfect order, with batteries and instructions. A real "snip" while they last: ONLY £7/10/- (postage, etc., 3/6).

UNIVERSAL AVOMETER 34 RANGE MODEL D

Ex-Air Ministry, but thoroughly reconditioned and checked. Supplied with internal batteries and instructions. Covers ranges as-follows:

D.C. VOLTS	A.C. VOLTS	D.C. Current	A.C. Current
150 mV.	7.5 v.	15 mA.	75 mA.
300 mV.	15 v.	30 mA.	150 mA.
1.5 v.	75 v.	150 mA.	750 mA.
3 v.	150 v.	300 mA.	1.5 amp.
15 v.	300 v.	1.5 amp.	7.5 amp.
30 v.	600 v.	3 amp.	15 amp.
150 v.	750 v.	15 amp.	
300 v.	1,500 v.	30 amp.	Resistance
750 v.			1,000 Ω
1,500 v.			10,000 Ω

ONLY £8/19/6 (Postage, etc., 3/6).

Cash with order please, and print name and address clearly

PLEASE ADD POSTAGE OR CARRIAGE COSTS ON *ALL* ITEMS

HARRIS ELECTRONICS (LONDON) LTD.

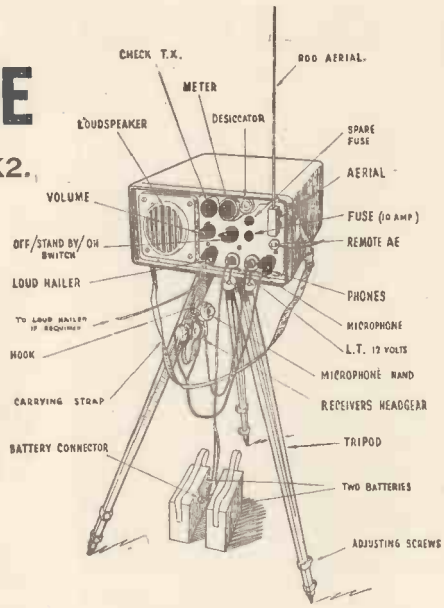
Radio Corner, 138 Gray's Inn Road, London, W.C.1. Phone: TERMINUS 7937

Open until 1 p.m. Saturdays. We are 2 mins. from High Holborn (Chancery Lane Station) and 5 mins. by bus from King's Cross.

Portable/Mobile

V.H.F RADIO TELEPHONE

TYPE W.S B44 MK2.



EXPORT ONLY

CRYSTAL CONTROLLED 60-95mc/s.

A modern 14-valve superhet receiver and AM transmitter using current series of B7g valves. Valve line-up: 2–CV136/7D9, 1–CV137/EAC91, 7–CV138/EF91, 4–CV416/6F17. Robust cast aluminium case includes 5in. loudspeaker. Internal vibrator pack (synchronous type) provides operation from 12-volt accumulators or vehicle or boat 12-volt supply, in fixed or mobile use. Available, less crystals and accessories, but with connecting plugs, ex-stock. Accessories and crystals for specified frequencies in the range 60–95 Mc/s can be supplied to order at extra cost.

Each unit is fully tested and in good condition. Price (including packing FOB London), £20 each.

Special quotation for quantities up to 500 sets.

---

50 MICRO AMP MOVING COIL METERS

Brand New & Boxed—Large Stocks available

Made on Government Contract by Famous British Maker

3⅛in. Square—800 ohms resistance. 4 Scales operated by lever "Set-zero"—"0–3"—"0–30"—"0–300." Easily coupled to rotary range switch by cord or lever. Ideally suitable for transistor tester, output meter, volt-milliameter. Adjustable to work as centre-zero 25-0-25 μA.

A RANGE OF METER BOXES

Useful for all kinds of testgear, a quality job in welded steel, finished in grey hammer stoved enamel. Standard panel size 4½" x 7¼", available in depths 2", 3", 4" and 6".

UNDRILLED: 2" **12/6**: 3" **13/-**: 4" **13/6**: 6" **15/-**. With panel punched to take one 50μA meter, add **1/6**, or to take two meters **2/6**.

Complete with data

ONE METER **19/6** (*plus post 6d in U.K.*)

TWO METERS **35/-** (*plus post 1/- in U.K.*)

SPECIAL PRICES FOR 100 LOTS

TEST GEAR COMPONENTS (LONDON) LTD

15 ARCANY ROAD, SOUTH OCKENDON, ESSEX *TEL: SOUTH OCKENDON 2610*

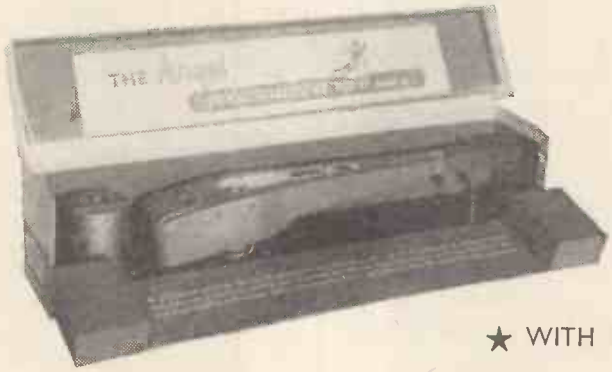
HARVERSON SURPLUS CO LTD

Phone: CHErrywood 3985/6/7 83, HIGH STREET, MERTON, S.W.19. Phone: CHErrywood 3985/6/7

The world famous E.M.I. Angel Transcription P.U.

SPECIFICATION

Physical
Length 15¾ inches (40.32 cms.).
Height 2½ inches (6.41 cms.)
With 2¾ inches (6.03 cms.)
Centre of base to stylus tip 12 inches (30.72 cms) Approx. overall.
Stylus
A diamond stylus is fitted to the 33⅓/45 r.p.m. head supplied
Head Impedance
1 ohm (measured at 1,000 c.p.s.).
Frequency Response
For a constant recorded velocity the frequency response is sensibly level within the following limits: with micro-groove stylus 20—16,500 c.p.s. With standard stylus 20—20,000 c.p.s.
Distortion
Measured at 400 c.p.s., the total harmonic distortion is less than 5% for a recording level of +20 db referred to 1 cm./sec. r.m.s. transverse velocity.
Sensitivity
50 mV at secondary of transformer provided from a recording level of +10 db referred to 1 cm./sec. r.m.s. velocity.
Weight at Stylus Point
Variable from 3—10 grammes as required.



★ (MODEL 17A)

A PICKUP FOR THE CONNOISSEUR ORIGINALLY PRICED AT £17/10/-. WE CAN OFFER THE LAST REMAINING FEW AT

£4 . 10 . 0

PLUS P. & P. 5/-.

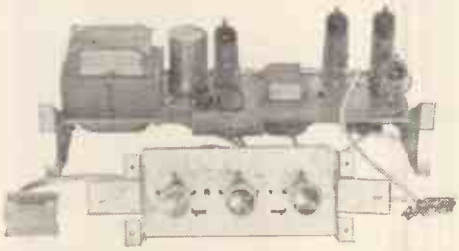
★ WITH DIAMOND STYLUS

SPECIAL OFFER FOR 1 MONTH ONLY

8 WATT Push Pull MONAURAL AMPLIFIER

By well-known manufacturer—employing four Mullard valves: ECC.83, 2 EL.84 and EZ.80. Bass, treble and volume on remote panel. Elegant knobs. **OUR PRICE**—Plus P. & P. 4/6. 50 only at **£4.19.6**

Also a few Stereo left.



PLESSEY TWEETER

This well-known Plessey 3 ohm Tweeter at our amazing price of . . .

12/6 TAX PAID
Plus P. & P. 1/6.

SPECIAL OFFER FOR 1 MONTH ONLY

Ex. Speaker, 5in. Goodman unit. Cabinet 8" x 6" x 2". Complete, includ- lead lead. P. & P. 2/-.

18/6

Amazing two scoops! Harverson does it again!

AM/FM RADIOGRAM CHASSIS

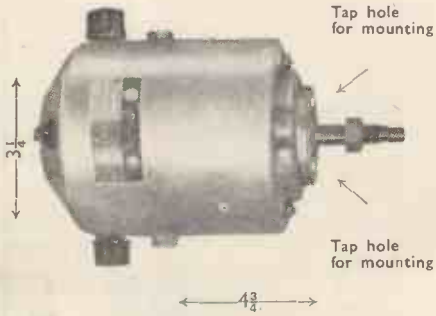
★ By famous manufacturer. ★ 200/250 volts A.C. ★ Coverage 1000-1900 m., 200-500 m., 88-98 mc/s. ★ Tuned by 5 "Piano Keys"—Off, LW, MW, FM and Gram. ★ Sockets for P.U., Ae, E. Extn. Spkr. and Dipole. ★ Tuning and tone controls fitted. ★ Valves, ECH81, EF89, EABC80, EL84, ECC85 and EZ80.

50 Only at ridiculous price of **10 gns.**, plus 8/6 P. & P.

TAPE RECORDER

★ CONTEMPORARY Red and White Tygan Cabinet. Size 13½ x 14½ x 9½ inches.
★ B.S.R. DECK.
★ MAGIC EYE tuning.
★ INPUTS for RADIO and MIKE.
★ VOLUME and TONE Controls.
This instrument has to be seen and heard to be believed.

Complete with ACOS Xtal Mike. ONLY 18 gns.



NOT GOVT. SURPLUS

⅙ H.P. 220-250 A.C. motor, ideal for lathe, coil winder, drill, saw motor, etc. Don't miss it. Dimensions: 6½ x 3½

29/6 P. & P. 2/3.

Wilkinsons EST. 1921

METERS GUARANTEED

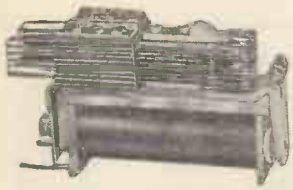
F.S.D.	Size	Type	Price
50 Microamps	2½in.	MC/FR	70/-
100 Microamps	2½in.	MC/FR	60/-
100 Microamps	3½in.	MC/FR	70/-
500 Microamps	2in.	MC/FR	22/6
500 Microamps	2½in.	MC/FR	37/6
1 Milliamp	2in.	MC/FS	27/6
1 Milliamp	2½in.	MC/FR	35/-
30 Milliamps	2½in.	MC/FR	12/6
100 Milliamps	2½in.	MC/FR	15/-
200 Milliamps	2½in.	MC/FR	15/-
500 Milliamps	3½in.	MI/FR	30/-
5 Amperes	2in.	MC/FS	27/6
15 Amperes	2in.	MC/FR	12/6
25 Amperes D.C.	2½in.	MI/FR	7/6
50 Amperes	4in.	MI/F/PR	65/-
30-0-30 Amp	2in.	MC/FR	15/6
50-0-50 Amp	2in.	MC/FS	12/6
10 Volts	2in.	MCR/FS	25/-
50 Volts	3½in.	MC/FS	45/-
300 Volts	2½in.	MI/FR	25/-

Postage on meters 1/6

Complete list available

METER RECTIFIERS 250μA 1 M.A., 5 M.A., F.W. bridge, **8/6**, post 6d.
CROSS POINTER METERS. 2 separate 100 microamp movements, **22/6.**
MICROAMMETER. 250 F.S.D. 3½in. F.R. Sangamo Mod. S37. Scaled for valve voltmeter. Circuit available free, **55/-**, post 1/6.
UNI-PIVOT GALVANOMETER by Cambridge Instruments, 50-0-50 microamps, dia. 4in. Knife pointer, mirror scale. Complete with leather carrying case. Ideal for laboratory use, **£10**, carriage 3/-.
PORTABLE VOLTMETER. 0-160 volts A.C./D.C., accuracy within 2%, 8in. mirror scale, knife pointer, in polished case. A precision moving iron instrument at a very low price, **£4/19/6**, post 3/6.
FLEXIBLE ALUMINIUM TUBING. A.P. 1½in. 3/6 per foot.
" " " " 1in. 2/3 " "
" " " " ¾in. 1/9 " "
" " " " ½in. 1/2 " "
WHEATSTONE BRIDGE 1 to 10,000 ohms, plug type, **£5**, carriage 7/6.
OSCILLOSCOPE No. 11 with high-class amplifier. 230 volts. **£12/10/-**, carr. 15/-.
AVO TEST BRIDGES. 220/240 volt A.C. Measure capacities from 5 pf. to 50 mfd. and resistances from 5 ohms to 50 megohms. Valve voltmeter range 0.1 to 15 volts and condenser leakage test. Full working instructions supplied with instrument. **£9/19/6**, post 3/-.
SLOW MOTION VERNIER DRIVE. Scaled 0–180°. Ratio 38:1, diam. 3in. **15/6**, post 1/6.
OSCILLOSCOPE. Type 43. With 3½in. C.R.T. 138A, 4—617, 3—VR54, 5Z4, VU120. Brand new with usual controls, power pack and leads. Suitable for 230 volts, **£10/10/-**, carriage 12/6.
FREQUENCY METERS. 45-55 Cycles per second 230 volts, 6in. dia, Flush Round. Brand new in maker's box, **£10/10/-**, post 3/6.

RELAYS P.O. TYPE 3000



Built to your own specification

Keen Prices

Quick Delivery

Contacts up to 8-Changeover

MINIATURE RELAYS:

Siemens High Speed Sealed.				S.T.C. and G.E.C. Sealed.		
2.2Ω+2.2Ω	H96A	15/6	2Ω	2 C.O.	4184GA	18/6
145Ω+145Ω	H96C	19/6	700Ω	2 C.O.	4184GD	19/6
500Ω+500Ω	H96D	22/6	2500Ω	1 make	HD4186EE	22/6
1700Ω+1700Ω	H96E	25/-	2700Ω	2 C.O.	4184GE	21/6
Siemens High Speed Open			180Ω	2 m 2 b	M1087	19/6
100Ω+100Ω	H85N	15/-	670Ω	4 C.O.	M1092	21/6
850Ω+850Ω	H85W	15/-	2500Ω	1 C.O.	M1022	22/6
1000Ω+1000Ω	H95A	17/6	5000Ω	2 C.O.	M1052	25/-

ERICSSON SEALED. Highly sensitive. 7000Ω 1 C O 24 v. 25/-.
Comprehensive range available from stock.

SWITCHES. 1 hole fixing, 3 amp. 250 volt. 1/6 each, 12/- doz.
RACKS—POST OFFICE STANDARD. 6ft. high with U-channel sides drilled for 19in. panels, heavy angle base, 4ft. 10in. in stock.

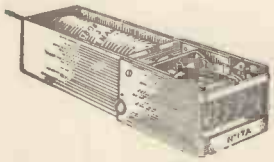
P.M. SPEAKERS. AXIOM 150 DUAL CONE 12in. 15 WATTS 15 OHMS FULLY DUSTPROOF, £7/19/6, POST 7/6.
PYE 10in. PORTABLE 3 OHMS 50/-, CARR. 7/6.
PLESSEY SEALED TYPE WITH 3in. ROUND GRILLE 19/6, POST 1/6.
ELAC 5in. ROUND, 3 OHMS, 15/6, POST 1/6.
JACK PLUGS. Cylindrical bakelite screw-on cover, 2 contact 2/6, post 6d.

SOCKETS. One hole fixing for above, 3/6, post 6d.
TERMINAL BLOCKS. 2-way 4/- doz. or box of 50 for 15/-, 3-way 6/- doz., 50 for 22/6, post 1/6.
TERMINAL STRIPS with ceramic supports from 2 to 24 ways @ 4d. per way.
MEGGER CIRCUIT TESTING OHM METERS. 0–1000 ohms and 100 ohms — 200K ohms INF, complete with spikes and leads. Brand New, 97/6, post 2/6.

Your Own Telephone 75/-

TELEPHONE SET TYPE "A." Ringing and Speaking both ways on a four-core cable. Carries the voice loudly and clearly over any distance. Two handsets are supplied as illustrated and the set is complete with Pushes, Buzzers, Battery, Plugs and Sockets. We can supply 4-core PVC cable at **10d.** per yard or 2-core at **3d.** per yard extra. Price **75/-** set, post 3/6.
TELEPHONE SET "TELE-F." This is the best known portable telephone ever made, it has a built-in generator for ringing the other instrument and requires only twin wire between the sets. The set of two instruments and batteries in carrying case, **£7/10/0**, post 7/6. Twin flat P.V.C. wire **3d.** yard.
TELEPHONE SET TYPE 'K.' The most compact telephone set available as the 4½ v. flat battery and buzzer is built-in to the hand instrument. Ringing and speaking both ways on twin wire, instrument is complete with 5 ft. flex. Easily hangs on the wall. Set of two instruments, **£5/10/-**, post 3/6.
ROTARY CONVERTERS. Input 12 D.C. Output 230 A.C. 50 cy. 135 watts. In fitted case with variable resistance, 0/300 voltmeter. The ideal job for T.V. and tape recorders where A.C. mains are not available. **£10**, carr. 15/-. Special connectors, one fitted with 6ft. heavy duty flex and clips for D.C. side, **10/-** set, post 1/-. **ROTARY CONVERTER**, input 12 v. or 24 v. D.C., output 230 v. A.C., 135 watts, **£8/10/-**, carriage 7/6.
BATTERIES. Portable Lead Acid type, 6 volts 125 ampere hours. In metal case 16in. × 18in. × 11in. (Two will make an ideal power supply for our 12 volt Rotary Converters.) Uncharged **£6/10/-** each, carriage 15/-. 24 volts 85 amperes, **£14** each, carriage 15/-.
GEARED CAPACITOR MOTORS. 220-240 v. 50 cy. 30 watts, 300 r.p.m., also spindle for 1425 r.p.m. A powerful and useful motor **75/-**, post 3/6.
BARTLETT DRYING OVEN. Interior dimensions 18in. × 15in. × 15in. Automatic temperature control. 230/250 volts A.C. 1500 watts. **£40**, carr. 30/-.
BAIRD & TATLOCK HOT AIR OVEN. Interior dimensions 14½in. × 12in. × 12in. Copper framed. Double Jacketed "Stabilec." 110/115 volts 14·8 amps., with adjustable temperature control. **£30**, carr. 20/-.
KEY SWITCH LOW CAPACITANCE (Henry & Thomas). 2 C.O. locking, **7/6** each. 4 C.O. Non-locking, **10/6** each. 6 C.O. locking, 2 C.O. locking, **17/6** each. Also 8 C.O. No lock (Muirhead), **17/6** each.
T.C.C. CONDENSERS. 0.1 Mfd. 31 kV. **75/-** each, 1 Mfd. 10 kV. **45/-** each.
SOLENOIDS suitable for remote control, mechanical indicators, etc. 12 v. D.C., 400 M.A., 30Ω, 3½in. arm, ½in. movement, **5/-** each, post 1/6.

RESISTORS EX STOCK, IN QUANTITY WIRE WOUND, HIGH STABILITY CARBON ETC., BEST MAKES AT LOWEST PRICE.



MAGNETIC COUNTERS

Counting to 9999.
2-6 v. D.C., **15/-** each, post 1/6.
75-230 v. D.C. **15/-** each, post 1/6
HIGH SPEED TYPE No. 100c. **35/-**, post 1/6.

VEEDER-ROOT MAGNETIC COUNTER. General purpose type with zero reset. 800 counts per minute up to 999,999. 48 volt D.C. **55/-**, post 2/6.
THERMOSTAT SATCHWELL, 12in. stem 0/250 volt A.C./D.C. 15 amps. A.C. 10 to 90 degrees cent. **25/-**, post 2/6.
ROOM THERMOSTAT. Adjustable between 45 and 75 deg. Fahr., 250 v. 10 amp. A.C. Ideal for greenhouses, etc., **35/-**, post 2/-.

THIS MONTH'S SPECIAL OFFER
TANNOY LOUD HAILER with 180 ohm line transformer and condenser. Impedance 7.5 ohms. Capacity 8 watts. Complete in slope front wood case, power microphone and built-in switch. **27/-**, post 5/6.

NIFE BATTERIES. Nickel Cadmium 12 volt 18 ampere hours crated and connected alkaline filled. Brand New **£4** each, carriage **10/-**. Also available 2.4 volt 10 ampere hours, **20/-** each, post 3/6.
TRANSFORMER Single Phase 250-115 volts 50 cycles 5 KVA double wound, **£30**, carriage extra.
FANS INDUSTRIAL TYPE 230/240 volt A.C. Capacity Motor, 16-inch blades in housing, adjustable louvres, filter. Brand New, **£25**, carr. extra.
AIR BLOWER powered by a 230-volt A.C. motor, 15 in. fan. Volume of free air at max. r.p.m. is 1,250 cu. ft. per min. At maximum efficiency 900 cu. ft. per min. Brand New **£25**, carriage 20/-.
EXTENSION SPEAKER in cabinet 9in. × 8in. × 4in. Permanent Magnet. 3 ohms. Ready for use, **25/-**. post 2/6.

L. WILKINSON (CROYDON) LTD.
19 LANSDOWNE RD. CROYDON SURREY
Phone: CRO 0839 Grams: WILCO CROYDON

A SELECTION OF P.A. SYSTEM EQUIPMENT FOR INDOOR OR OUTDOOR USE

VORTEXION PORTABLE AMPLIFIER

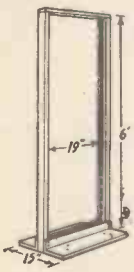
A first-class amplifier for 200/250v.A.C. or 12v. D.C. operation. 12 watt push-pull output matched to 7.5, 15, 250 or 500 ohms. Incorporates inputs for mike and gram, volume control and bass and treble control. Good working order. **ONLY £9/19/6.** Carr. 10/6.

NEW AND UNUSED ACCUMULATORS

12 v. 25 A.H. (as on left) 45/-. Carr. 7/6. Ideal for use with above Amplifier

2 v. 100 A.H. 75 actual (ex Govt.), with carrying handle. Size 6½ x 6½ x 3½in., 15/- each. Carr. 3/6. **2 v. 16 A.H.**, as above. 7½ x 4 x 2in., 5/- each. P. & P. 2/-. 6 for 24/-. P. & P. 10/-. **2 v. 14 A.H.**, as above (less handle). 7 x 2½ x 2½in., 5/- each. P. & P. 2/-. 6 for 24/-. P. & P. 10/-.

ROTARY CONVERTER. 24 v. D.C. to 230 v. A.C. 50 cycles, 150 watts. Brand new and unused. **£8/10/-.** Carr. 7/6. Ditto. 100 watts **£6/9/6.** Carr. 7/6.
ROTARY CONVERTER. Ex-Govt. 12 v. D.C. input 230 v. A.C. output 50 cycles at 135 watts. Complete in carrying case with lid. Voltage control. sliding resistance, mains switch and 0-300 v. A.C. flush meter. In good condition **£10.** Carr. 10/-.
Motor only, without case, etc. Brand new and unused, **£8/10/-.** Carr. 5/-.



G.P.O. RACKS

19in. Heavy duty, all steel Standard drilling.
5ft. 6in. angle uprights. **£3/10/-.** Carr. 15/-.
6ft. channel uprights (as illustrated) **£5.** Carr. 15/-.
7ft. channel uprights. **£6.** Carr. 15/-.
19in.x14in. PANEL SHELF in 14 s.w.g. steel. Suitable for above racks. **15/-.** P. & P. 5/-.

HEAVY DUTY—ALL STEEL

TRIPOD STANDS

Adjustable every 6in. to approx. 9ft. 6in. when fully extended. (Folds up to only 4ft. 6in. for storage). Suitable for outdoor speakers, public address systems, floodlighting, etc., etc.

OUR PRICE **£3.10.0** Carr. 5/-.

These stands are ideal for our RE-ENTRANT LOUD HAILER as described above.

HAND MICROPHONE. Electro-dynamic. Suitable for use with our Portable Amplifier. With built-in on/off switch and rubber mouthpiece for outdoor work. **30/-.** P. & P. 2/-.

TWO SPECIAL ITEMS

WESTALITE RECTIFIER UNIT. Type 925. A.C. input 200/250 v. or 440/440 v. 50/60 cycles, 3 phase. D.C. output 13–0–13 v. by 1 volt steps to 16–0–16 v. at 120 amps. Metered, switched and fused throughout. Brand new and unused. **£75** ex-stores.

WESTALITE TRANSFORMER RECTIFIER. Oil filled. Primary 380–440 v. 50 cycles. 3 phase. Supply 20 v. D.C. at 200 amps (conservative rating). Complete with original control panel. Perfect condition, unused. **£150** ex-stores.

MARCONI SIGNAL GENERATOR. TYPE TF517-F/1. Covering 10–18 Mc/s. 33–58 Mc/s. 150–300 Mc/s. In very good condition. Complete with full technical data and instructions. Unrepeatable at only **£12/10/-.** Carr. 20/-.

MARCONI SIGNAL GENERATOR TYPE TF390G. for 200–250 v. A.C. mains input. Frequency range 4–16 Mc/s. and 32–100 Mc/s. indirect calibration. Output 1μV to 100 M/V. 400 c/s internal modulation. In good order. Only **£12/10/-.** Carr. 20/-.

BRAND NEW CRYSTAL CALIBRATOR No. 10. (Battery powered 1.4 v. valves.) Complete with full working instructions, circuit diagram, carrying haversack, connecting lead and spare valves. Frequency range: 1.5 to 10 Mc/s. (nominal) but can actually be used up to 30 Mc/s. Weight 5lb. Size 7in. x 7½in. x 4in. A miniature B.C.221 in every respect. A must for every laboratory, etc. ONLY **£4/19/6.** P. & P. 2/6.

MULLARD BRIDGE. Type GM. 4140/1 Mains operated from 100–250 v. A.C. Will test resistances from 0.1 ohm to 10 megohms and condensers from 10pf. to 10mfd. Good condition and complete with instruction booklet. **£6/19/6.** P. & P. 2/6.

RECORDING TAPES. Super quality P.V.C. 1,800ft. L.P. 7in. spools, **30/-**; 1,200ft. Std. 7in. **19/-**; Empty 7in. spools 3/9 each. Send S.A.E. for Tape Bargain List.

EVERSHED AND VIGNOLES MEGGER CIRCUIT TESTER (low reading ohm meter). 2 ranges. 0–3, 0-30 ohms. The perfect meter for continuity and polarity testing, complete with test leads and ready to use. Brand new. Only **£4/17/6.** P. & P. 3/-.
BRIDGE MEGGERS. Evershed and Vignoles. Series 2 in perfect condition. 250 v. **£22.** Carr. paid. Leather case available at **20/-** extra.

TELEPHONE SETS (TELE "F") Housed in Bakelite cases, complete with built-in ringing generators and batteries. Ideal between two or more positions up to practically any distance. Tested before despatched. ONLY **70/-.** P. & P. 3/6. 2 sent for **£6/10/-.** Carr. paid.
TELEPHONE CABLE. Twin one-mile drums (Don 8), **£5.** Carr. 20/-. Single one-mile drums (Don 3), **50/-.** Carr. 7/6.

6 kV/A. AUTO-TRANSFORMER. 230/110 v. 50 cycles (fully tapped primary and secondary). Capable of 25% over actual rating. Brand new and unused, **£18.** Carr. 20/-. Also **3 kV/A** as above, **£12/10/-.** Carr. 20/-.

20 kV/A AUTO-TRANSFORMER. 230/115 v. 50–60 cycles, by Jefferies Transformer Co., U.S.A. Perfect condition, **£20.** Carr. £1.

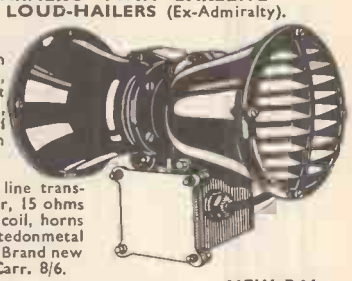
Limited Quantity Only ! !

TRANSMITTER TYPE T.1945

As used for Air-Sea Rescue. This transmitter is a non-directional sono-buoy. The freq. band of 62.9 Mc/s to 71.7 Mc/s is divided into 12 channels spaced 800 kc/s apart, each buoy being set up to one of the channels. (Most channels available.) H.T. power supply is from 3-45 v. batteries, L.T. 1.5 v. Absolutely brand new and complete in tropically sealed packing (less batteries).
HOME AND EXPORT ENQUIRIES INVITED

RE-ENTRANT LOUD HAILERS (Ex-Govt.) Heavy duty 20 watts all-metal 15 ohms. Diameter. 15in., length 15in. (approx) good condition **£6/10/-.** Carr. 10/-. Ditto. Brand new, **£8.** Carr. 10/-.

PARMEKO TWIN BAKELITE LOUD-HAILERS (Ex-Admiralty).



Length 15 in., Height 9 in., dia. of horn 8½in.

With line transformer, 15 ohms voice coil, horns mountedonmetal base. Brand new **£3.** Carr. 8/6.

NEW P.M. HEAVYDUTY SPEAKERS Complete with O.P. trans, in all steel blue-grey double grilled cabinet. 6in. 30/- 8in. 32/6 Carr. 3/6 each

10inch Speaker in wooden cabinet, size approx. 14"x16" x8"with padded interior and volume control. **50/-.** Carr. 3/6.

FLARE HORN. 30in. x 12in. x 26in. long. Driven by Heavy duty 3 ohm P.M. Speaker. Ideal for music, etc. **£7/10/0.** Carr. 10/-.

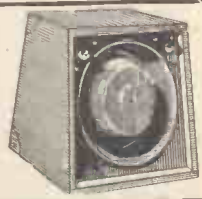
EXPONENTIAL HORNS by famous manufacturer of P.A. systems.

15 watt, 30in. long, 20in. square flare, 15 ohms speech coil. Good condition, **£7/10/6.** Carr. 10/-.

VITAVOX PRESSURE UNITS TYPE N. Heavy Duty. Special quality. 20 watts P.M. Brand new **80/-.** Carr. 5/-.

BAKER'S SELHURST SPEAKERS
12in. P.M. 15 ohms 15 watts, 30–14,000 c.p.s. Our price **£4/10/-.**
"AUDITORIUM" 12in. 15ohms, 12 watts, 35–16,000 c.p.s. Flux density 14,500. OUR PRICE **£7/10/-.**
"SUPER HI-FI 25" 12in., 15 ohms, 25 watts 25–20,000 c.p.s. Flux density 17,600. OUR PRICE **£9/9/-.** All are brand new and full descriptive specification is available.

TRUVOX TANNOY LOUD-HAILERS



With 180 ohm line transformer and condenser. Impedance 7½ ohms, handling capacity 8 watts. Complete in slope-front wooden case. Brand new **25/-.** Carr. 4/6.

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ACHLDDD	10/–
AC/P	7/6
ACSPENDD	26/6
AC6PEN	6/6
ATP4	3/6
AZ1	10/–
AZ31	10/–
AZ41	13/11
B36	10/–
CBL1	26/6
CBL31	23/3
CCH35	23/3
CL4	12/6
CL33	19/3
CY31	16/7
CY1	18/7
CY73	4/–
C36A	6/6
D42	4/6
DAF96	8/–
DF96	8/9
DH63	7/6
DH101	8/–
DK96	8/–
DL63	9/–
DL82	10/6
DL96	8/–
DM70	7/6
DN41	12/6
EA50	1/6
EABC80	9/–
EAF42	10/6
EB34	2/–
EB41	8/6
EB91	6/6
EBC33	6/9
EBC41	9/6
EBC81	11/4
EBC90	12/7
EBC91	12/7
EBF80	9/9
EBF89	9/6
EBL21	23/3
EBL31	23/3
ECC40	23/3
ECC81	8/–
ECC82	7/6
ECC83	9/–
ECC84	10/–
ECC85	9/6
ECF80	12/–
ECF82	13/–
ECH3	26/6
ECH21	23/3
ECH35	23/3
ECH42	9/6
ECH81	9/–
ECH83	13/11
ECL80	9/–
ECL82	12/6
ECL83	19/3
EF9	23/3
EF22	8/6
EF36	4/–
EF37A	15/–
EF39	5/9
EF40	14/6
EF41	9/9
EF42	11/–
EF50	4/–
EF50SYL	7/–
EF54	6/–
EF55	10/–
EF80	7/6
EF85	7/6
EF86	13/–
EF89	8/9
EF91	5/9
EF91(BVA)	9/–
EF97	13/3
EF98	13/3
EK32	7/–
EL32	4/6
EL33	14/–
EL34	15/–
EL36	19/11
EL38	26/6
EL41	10/6
EL42	10/6
EL81	16/7
EL83	19/11
EL84	9/–
EL91	5/6
EL821	26/6
EM34	9/6
EM80	10/–
EM81	10/6
EY51	9/–
EY81	13/3
EY86	10/–
EZ35	16/7
EZ40	7/6
EZ41	7/6
EZ80	7/–
EZ81	7/–
EZ90	7/6
E1148	2/–
FC4	26/6
FC13	6/6
FW4/500	10/–
GTIC	27/6
GZ32	12/–
H30	5/–
H63	10/–
HL23DD	8/6
HL22	6/6
HN309	24/7
K40N	9/–
KF35	8/6
KK32	21/11
KLL32	24/7
KT2	5/–
KT24	5/–
KT32	14/–
KT33C	8/6
KT36	29/10
KT61	13/6
KT63	7/6
KT66	17/6
KT74	6/6
KT76	6/6
KT88	22/6
KT101	9/–
KTW61	6/6
KTW63	7/6
KTZ41	3/6
MH41	6/–
MHL4	7/6
ML4	8/6
MS4B	10/–
MSP4/5	7/6
MSP4/7	7/6
MSP41	6/–
MX40	12/6
N37	19/11
N78	19/11
N147	14/6
N339	17/6
OZ4	5/6
P61	3/6
PABC80	13/11
PCC84	9/–
PCC85	11/6
PCC88	23/11
PCC89	19/11
PCF80	9/6
PCF82	12/6
PCF84	16/7
PCL82	12/–
PCL83	14/6
PL38	26/6
PCL84	13/6
PL36	14/6
PL81	11/–
PL82	8/6
PL83	11/6
PL84	12/7
PL820	18/7
PX25	12/6
PY31	16/7
PY32	17/11
PY80	7/6
PY81	8/6
PY82	7/–
PY83	8/6
PZ30	19/11
PEN4DD	26/6
PEN4VA	10/–
PEN25	6/–
PEN46	7/–
PEN383	23/3
PEN220A	4/–
PEN45DD	26/6
PENA4	12/6
PM12M	8/–
QP21	5/–
R16	26/6
SP41	3/–
SP61	3/–
SP4/S	10/6
SP4/7	10/6
T41	23/3
TH233	33/2
TP25	10/–
U10	10/6
U14	8/6
U16	12/6
U22	8/–
U25	17/11
U26	10/6
U37	26/6
U45	15/–
U50	8/–
U76	8/–
U81	8/–
U82	8/–
U101	8/–
U339	12/–
U403	16/7
U404	11/4
U801	29/10
UABC80	10/–
UAF42	9/6
UB41	9/–
UBC41	8/6
UBC81	11/4
UBF80	9/6
UBF89	13/11
UBL21	23/3
UC92	13/3
UCC84	10/11
UCC85	9/6
UCF80	16/7
UCH21	23/3
UCH42	9/6
UCH81	10/6
UCL82	16/7
UCL83	13/6
UF41	9/–
UF42	17/3
UF80	13/11
UF85	9/–
UF86	17/11
UF89	9/–
UL41	10/–
UL44	26/6
UL46	26/6
UL84	9/–
UU6	19/11
UU8	26/6
UY1N	12/6
UY41	7/6
UY85	7/–
VP13C	3/6
VP133	15/–
VR22 (PM2A)	3/–
VP23	6/6
VP41	8/6
VR105/30	8/–
VR116	4/–
VR150/30	7/6
VU120A	3/6
VU111	2/6
VU39 (MU12/14)	8/9
W21	10/–
W76	7/6
W77	8/6
W101	8/–
W729	10/6
W61	6/–
W61 (M)	8/–
X22	12/6
X41M	12/6
X101M	8/–
Y63	7/6
Z21 (4 pin)	2/6
Z309	7/6
Z359	7/6
1A3	3/6
1A7GT	12/6
1C2	11/6
1C5GT	12/6
1D5	12/6
1D6	12/6
1H5GT	9/–
1L4	6/6
1LD5	3/6
1N5	10/6
1R5	7/6
1S4	10/6
1S5	6/6
1T4	6/–
2C26	1/6
2P	26/6
3A5	12/6
3A8GT	6/–
3D6	5/–
3Q4	8/–
3Q5GT	9/6
3S4	7/6
3V4	8/6
4D1	3/–
5R4GY	9/6
5U4G	6/6
5V4	11/6
5Y3G	8/–
5Y3GT	8/–
5Z4G	9/–
5Z4M	10/–
6A7	10/–
6A8G	9/–
6AC7	4/–
6AG5	5/6
6AK5	5/–
6AL5	4/–
6AM5	7/6
6AM6	4/–
6AQ5	7/6
6AT6	8/6
6AU6	10/6
6B8G	4/–
6BA6	7/6
6BE6	7/6
6BG6G	23/3
6BH6	9/–
6BJ6	9/–
6BR7	12/6
6BW6	9/–
6BW7	8/6
6C4	4/6
6C5GT	6/6
6C6	5/–
6C9	17/3
6C31	7/6
6CD6G	29/10
6D6	5/–
6CH6	8/6
6F6G	7/6
6F6M	7/6
6F1	14/–
6F13	14/–
6F14	26/6
6F15	14/–
6F18	15/3
6F23	18/7
6F33	7/6
6H6	2/6
6H6GT	2/6
6J5G	3/6
6J5GT	5/–
6J5M	6/6
6J6	6/–
6J7G	6/6
6K7G	4/–
6K7M	6/9
6K8G	7/6
6K6GT	7/–
6K7GT	5/9
6K8GT	10/–
6K25	19/11
6L6G	8/–
6L6M	9/6
6L7G	7/6
6L1	23/3
6L18	11/6
6L19	13/6
6LD20	15/11
6M1	17/3
6N7GT	7/6
6P1	19/3
6P26	19/11
6P28	26/6
6Q7G	7/6
6Q7GT	9/6
6SA7GT	8/–
6SG7	7/6
6SH7	4/6
6SJ7	8/6
6SK7	6/–
6SL7GT	8/–
6SN7GT	7/6
6SQ7	9/3
6U4GT	12/–
6U5G	8/6
6U7G	8/6
6V6G	6/–
6V6GT	7/9
6X4	7/6
6X5G	7/–
6X5GT	7/–
6/30L2	12/6
7B6	10/6
7B7	8/6
7B8	6/–
7C5	8/–
7C6	8/–
7D6	13/6
7H7	9/–
7Q7	9/–
7S7	9/6
7Y4	8/6
8D2	2/9
9D2	3/6
10C1	17/3
10C2	17/6
10D2	12/–
10F1	12/6
10F3	23/3
10F9	15/3
10F18	15/3
10L1	15/11
10LD11	12/–
10M2	23/3
10P13	15/–
10P14	19/3
12A6	5/–
12AH8	12/–
12AT6	10/6
12AT7	7/6
12AU6	8/–
12AU7	8/–
12AX7	8/–
12BA6	9/–
12BE6	9/–
12C8	9/–
12H6	3/6
12J5GT	3/–
12J7GT	10/6
12K7GT	7/6
12K8GT	13/6
12K8M	13/–
12Q7GT	7/6
12SG7	7/6
12SH7	6/–
12SJ7	6/–
12SK7	6/–
12SL7	8/–
12SN7GT	10/–
12SQ7	8/6
14S7	17/–
15D2	7/9
19AQ5	9/9
19BG6G	23/3
20D1	15/3
20F2	26/6
20L1	26/6
20P1	26/6
20P3	23/3
20P5	23/3
25A6G	10/6
25L6GT	10/–
25Z4	9/6
25Z5	8/–
25Z6	10/–
27SU	19/11
30C1	10/6
30F5	10/6
30FL1	10/6
30L1	19/11
30L15	23/3
30P4	15/–
30P12	12/6
30P16	9/6
30PL1	12/6
30PL13	21/11
35L6GT	10/–
25Y5	9/9
35W4	7/6
35Z4GT	8/–
42	8/–
35Z3	16/7
35Z5GT	9/–
50C5	11/6
50CD6G	29/10
50L6GT	8/6
75	10/6
77	6/–
78	7/6
80	8/6
142BT	3/6
185BT	33/2
210DDT	4/6
210VPT	3/6
83	10/–
807	6/6
954	2/–
955	4/–
956	3/6
5763	9/–
9004	5/6
9006	5/6

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SMD1 Philips 209U	6/3
SMD6 Ultra Twin 50	5/3
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SMD30 KB Rhapsody, MP151/1	6/9

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4in. Square Units by Elac	19/6
5in. Round Units by Goodman, Celestion and Plessey	16/6
6½in. Round Units by Celestion	17/6
8in. Round Units by Goodman, Elac	18/6
10in. Philips Type with tweeter	27/6
10in. Round Units by Elac	22/6
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8in. x 5in. Units by Celestion and Richard Allen	25/6
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50K x 50K Log, 100K x 100K Log, 500K x 500K A/Log, 1 Meg x 1 Meg Log, 250K x 250K Log, 1 Meg. x 1 Meg. Linear, 500K x 500K Linear. All 6/6 each.

SWITCHES, WAVE CHANGE SWITCHES, etc.

3 pole, 4 way	3/– each
4 pole, 3 way	3/– each
1 pole, 4 way	2/– each
1 pole, 12 way	3/– each
2 pole, 6 way	3/– each
4 pole, 4 way	4/6 each
3 pole, 3 way	3/– each
3 pole, 3 way, 3 bank	2/3 each

ACOS MICROPHONES

Acos Mic 39/1. Crystal Stick Microphones for use as a hand, desk or floor stand unit for high quality recording, broadcasting and public address work. List Price £5/5/-. **OUR PRICE 39/6.** With table stand 47/6. With floor stand adaptor 52/6. Postage 1/6.
Acos Mic 40, as supplied with most modern tape recorders, with folding rest and 8ft. lead, response 40-6,000 c.p.s. Listed at 35/-. **OUR PRICE 25/-.**

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Monarch UA8, 4-speed automatic record changers with Ful-Fi turnover crystal cartridge, £6/19/6. Carriage 3/6.
BSR Monarch UA12. 4-speed unit. Ful-Fi Turnover Crystal Cartridge. Attractively styled in two colours of Cream and Pastel Green, £8/19/6.
Collaro Conquest, 4-speed fully mixing changer complete with Studio "O" crystal cartridge, £7/19/6. Carriage 3/6.
Collaro RC475 High Fidelity. 4-speed Automatic Record Changer with Turnover Cartridge, £7/19/6.
Garrard RC120/D, Mk. II, 4-speed unit manual control to enable records to be played singly, £8/19/6. Carriage 3/6.

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Latest Collaro Studio Tape Transcriptor. 3 motors, 3-speed, 1⅞, 3¾, 7½ i.p.s., takes 7in. spools. Push-button controls. Price £15/15/-. Tape extra. Carr. & Ins. 12/6.
Latest B.S.R. "Monardeck," single-speed, 3¾ i.p.s., takes 5¾in. spools. Simple controls. Price £9/19/6. Tape extra. Carr. & Ins. 12/6.

Best Quality Recording Tape

1,200ft. on 7in. spool	21/-
850ft. on 5¾in. spool	18/6
600ft. on 5in. spool	13/9
200ft. on 3¼in. spool	5/3

Collaro Junior
Single 4-speed record player unit in cream, complete with pick-up fitted turnover cartridge. Special Price 75/- each. Post 3/6.

Garrard GC2 Crystal Cartridge. Black moulded case complete with Standard and LP styli. Price 15/6.

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PANL-Air drying Paint Black Crackle (Crystalline Black), 3/- tin

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ALPHA RADIO SUPPLY CO.

103 LEEDS TERRACE, WINTOUN STREET

LEEDS 7

TERMS: Cash with order or C.O.D. Postage and Packing charges extra, as follows: Orders value 10/- add 1/-; 20/- add 1/6; 40/- add 2/-; £5 add 3/- unless otherwise stated. Minimum C.O.D. fee and postage 3/-.
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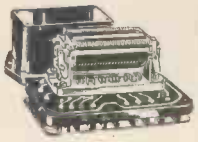
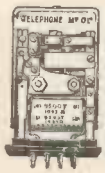
SLIDER RESISTANCES. New, 2 amp. 500 ohms, size 14in. x 6in., plus handle 6in., **27/6.** P. & P. 3/6.



SOLENOID OPERATED MAGNETIC RELAY. Type 5CW/3945, 4 pole changeover, 10 A contacts 24 v. operation. Brand new **13/6.** P. & P. 1/6.

NEW CARPENTER'S TYPE POLARISED RELAYS. 2 x 9,500 turns at 1,685 ohms. Price **22/6** each. P. & P. 1/-.



Carpenter's, similar to above, but type 5A48. Coils 1 x 3200 turns at 100 ohms and 1 x 2000 turns at 145 ohms, **22/6** each. P. & P. 1/-. Bases for same 2/6

SIEMENS H.S. RELAY. Very latest type, sealed. H96E. 1,700 ohms plus 1,700 ohms, single C.O. contacts. Brand new with fixing clip. In maker's cartons. Price **16/6** each, plus 1/- P. & P.

Siemens sealed similar relay to above, but 2.2 ohms plus 2.2 ohms. Minus clips, **12/6** each. Plus 1/- P. & P.

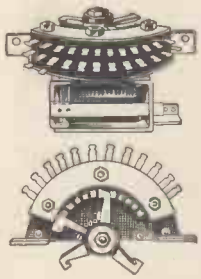
SUPERIOR BRAND NEW RELAY. 7,000 ohms coil. Will pull in at 750 microamp. and out at 450 microamp. Change-over platinum contacts. Vacuum sealed, will therefore not be affected by oil, moisture or water and never needs adjusting. Weight 2½ oz. Price **18/6** P. & P. 1/-.

MINIATURE MOVING COIL DIFFERENTIAL RELAY. Two coils 350 ohms each.

Operating current minimum 140 microamp., nominal 400 microamp, maximum 8 milliamp. One pole two way, or, centre stable. Two way contact current 100 mA. at 50 V. A.C. or D.C. Size 1¼ x ⅝ x ⅝in. Price **22/6** each.

ROTARY RELAY. 12 volt. Heavy duty change-over contacts and one low current for external circuit, plus one break set. Price **7/6.** P. & P. 1/6.

NEW WIRE WOUND RHEOSTAT ON CERAMIC. 58 ohm. 50 watt, complete with instrument knob. Price **8/6.** P. & P. 1/6.



MINIATURE UNISELECTOR SWITCH. Two banks of ten plus home contacts one bank continuous of normal. 30 ohm coil for 24 volt operation. Brand new, manufacturer's packing. Price **22/6** each. P. & P. 2/6. As illustrated.

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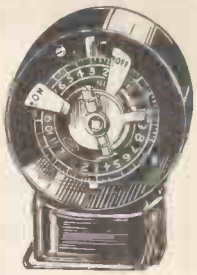

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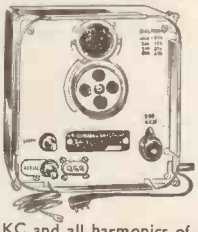

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1S4	8/6	6BW6	7/9	6L6	9/9	7K7	8/-	1487	14/9	80	6/6	DK96	7/9	ECH81	8/3	EZ40	6/9	PCF82	7/6
1S5	5/3	6BW7	6/6	6L6G	7/6	7Q7	9/6	19AQ5	7/6	83	9/6	DL33	8/9	ECL80	7/6	EZ41	7/3	PCL82	8/6
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3Q4	7/3	6C9	9/6	6LD3	8/6	7Z4	7/6	20P1	11/6	807A	5/-	DL94	7/-	EF39	4/3	G334	12/6	PEN46	5/3
3Q5GT	8/9	6CD6G	18/6	6LD12	7/6	8D3	3/6	20P3	12/6	807E	3/9	DL96	7/9	EF40	13/6	GZ37	10/6	PL33	9/-
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5R4G	9/6	6D2	3/9	6P1	14/-	10C14	9/-	25A6G	8/-	955	3/9	EAC91	4/9	EF50-BR	2/-	KL35	7/9	PL81	9/9
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5V4G	9/6	6D6	4/9	6P28	12/6	10F9	10/3	25L6GT	9/-	5763	10/-	EB34	1/6		2/6	KT33C	6/6	PL83	7/6
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5Y3GT	6/6	6F6G	6/3	6Q7GT	9/3	10LD3	8/3	25Z4G	7/3	9002	4/9	EB91	3/9	EF80	5/3	KT44	9/6	PM84	9/9
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5Z4	11/-	6F12	3/6	6SA7	5/9	10P13	9/6	25Z6	9/-	ATP4	2/9	EBC33	5/-	EF86	10/3	KT61	9/-	PY31	8/3
5Z4G	8/6	6F13	6/9	6SG7	4/9	10P14	9/6	27SU	16/-	AZ31	9/-	EBC41	8/6	EF89	8/-	KT63	6/6	PY32	10/6
5Z4GT	11/-	6F14	9/6	6SH7	4/6	10P18	8/-	30C1	7/6	B36	8/6	EBC81	7/9	EF91	3/6	KT66	12/6	PY80	7/-
6A7	10/-	6F15	9/6	6SJ7	5/-	12A6	5/3	30F5	7/-	B65	4/9	EBF80	8/6	EF92	4/9	KT76	9/6	PY81	6/6
6A8G	9/6	6F16	8/6	6SK7	5/3	12AH7	6/9	30FL1	9/6	CBL31	21/-	EBF89	8/6	EF95	6/9	KT81	14/-	PY82	6/9
6A8GT	13/6	6F33	6/9	6SL7GT	6/-	12AH8	9/9	30L1	7/9	OCH35	7/6	EBL21	14/-	EK32	7/9	KTW61	5/6	PY83	8/-
6AB8	8/3	6G6	3/-	6SN7GT	4/9	12AT6	7/9	30P4	12/6	CL33	18/-	EBL31	21/-	EL32	4/6	KTW63	4/9	PZ30	12/-
6AC7	4/3	6H6	2/-	6SQ7	6/3	12AT7	5/9	30P12	8/-	CY31	9/9	EC52	3/9	EL33	9/-	KTZ63	5/6	R18	12/6
6AG5	4/3	6J5	4/3	8SS7	5/-	12AU7	6/6	30P16	7/9	D63	1/6	EC90	3/6	EL35	8/6	L63	2/9	R19	12/-
6AG7	8/-	6J5G	2/9	6U4GT	10/6	12AX7	7/-	30PL1	10/6	D77	3/9	EC91	4/6	EL37	11/6	LN152	7/6	SD6	9/-
6AK5	6/9	6J5GT	3/9	6U5G	6/3	12BA6	8/-	35L6GT	9/-	D152	6/6	ECC31	9/6	EL38	12/6	LZ319	7/6	SP6	3/9
6AL5	3/9	6J6	4/-	6V6G	5/6	12BE6	8/9	35W4	6/9	DA30	12/6	ECC32	4/-	EL41	8/6	MU14	8/-	SP61	2/6
6AM5	4/6	6J7	7/9	6V6GT	6/6	12BH7	10/6	35Z4GT	5/6	DA90	2/6	ECC33	4/9	EL42	9/6	N37	11/-	SU25	15/-

SU2150A	4/6	UCL82	11/3																
T41	7/6	UCL83	13/6																
TH30C	12/6	UF41	8/6																
U14	8/-	UF42	6/9																
U18	8/6	UF80	9/-																
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U25	13/6	UF89	7/3																
U26	11/-	UL41	7/6																
U31	7/3	UL44	12/6																
U33	13/-	UL46	9/9																
U35	8/9	UL84	7/9																
U37	26/6	UM80	9/6																
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U50	6/-	UU7	9/6																
U52	5/-	UU8	25/-																
U76	5/6	UY1N	11/-																
U78	5/6	UY21	11/6																
U107	11/-	UY41	6/6																
U191	9/6	UY85	6/9																
U281	9/6	VR105/30																	
U282	15/-		7/-																
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U309	12/6		5/6																
U329	12/6	W61M	11/-																
U339	11/-	W76	5/6																
U404	6/6	W77	4/9																
U801	18/-	W81	5/9																
UABC80	8/9	X61M	12/6																
UAF42	9/-	X63	9/6																
UB41	8/-	X65	11/-																
UBC41	8/3	X66	11/-																
UBC81	10/-	X76M	9/6																
UBF89	8/6	X78	14/6																
UBL21	14/6	X79	16/6																
UCC84	14/6	Y63	6/3																
UCC85	8/-	Z63	5/3																
UCF80	16/-	Z66	9/6																
UCH21	14/6	Z77	3/6																
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SIMPLE EFFICIENT

Speech communication

TELERADIO 5A
RADIO TELEPHONE

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Only six controls, no technical skill required.

SIZE
In one attractively finished case, 9" x 16" x 20".

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High-performance receiver tunes over a useful portion of the short-wave band, to provide general entertainment.

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A.W.A. provides a complete equipment ready for connecting to the battery. Full details given on aerials.

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The 5A works on a 12 Volt battery. Only 3.2 Amps. drain when receiving.

The A.W.A. Teleradio 5A breaks down the barrier of isolation in outback areas. Trained operators are not required. The equipment uses the most modern valves and design features to provide simplicity of operation and efficiency.

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TRANSFORMERS, potted, "C" core; Input **230 v.** Outputs:— 6.3 v., 0.3 A. (1 A. actual), twice, **8/6;** Outputs:—510-0-510 v. 275 mA, 375-0-375 v. 83 mA, 5 v. 3 A., 6.3 v. 7 times (17 A.), **65/-. CONDENSERS,** block, paper; 8 mfd. 250 Vw. **4/-;** 600 Vw. **6/-;** 4 mfd. 2 kVw. **7/6;** 600 Vw. **3/6.** Switch fuse splitter, DP, 15 A. **15/-.** Panel fuseholders, **1/3;** Panel Lampholders (indicators), **1/6. POWER UNITS.** Input A.C. 115/250 v. Outputs: D.C. 330 v., 120 mA. and 6.3 v. A.C. twice. Potted trans. and LF choke, new (post 3/6), **30/-. MONITOR 56,** triggered oscilloscope, comprising **Indicator 248** and **Power Unit 675.** Valves VCR138a, 3/EF50, 2/ECC33, 5/EF55, EF37A, 6V6, 3/EA50 and 2/5U4G, VU120A. Two units each 12×9×18in., black finish. 230 v. A.C. input with 18-way cable and mains cable and circuit. Cathode probe unit extra, **17/6, £8/10/-** (Rail 20/-). **INDICATORS, Type 101** with VCR530 and 2/EB91, 2/EF91, 2/R10, new cond., **30/-** (post 7/-). **Type 1** with VCRX263, 2/EF52, 5/6J6, 1/6V6, 1/EY51, 2/EB91, 3/EF91, RF EHT Generator and 28 kc/s, xtal, **45/-** (Rail 7/6). **HEADPHONES-** CLR, **7/6. CR100** Noise Limiter assemblies, with valve, **3/6. NEW M.C. METERS,** 3½in. round flush, 50μA, **70/-;** 200μA, centre zero, **50/-;** 1 mA, centre zero, **45/-;** 1 mA, **55/-;** 2½in. 1 mA, **22/6;** 2in. 300 mA, each **8/6.** 2½in. M.I. 20 v. A.C., **8/6;** 300 v. A.C. 2½in., **15/-. VIBRATORS,** Mallory G634C 12 v. 4-pin, **7/6;** 6 v. 5-pin reversible, **7/6. R1155B,** good condition, tested with handbook. **£7/10/-** (Rail 10/-). **DRIVES:** slow-motion Admiralty 200 : 1 ratio, scaled 0-100, **5/6. R1155 S.M.** "N" type, new, **10/6. VIBRAPAK** 6 v. D.C. to 250 v. 60 mA, smoothed case, **22/6.** 12 v. to 250 v. 60 mA, **21/-** (p.p. 3/6). **DYNAMOTORS** (post 3/6). 12 v. to 250 v. 65 mA, **11/6;**

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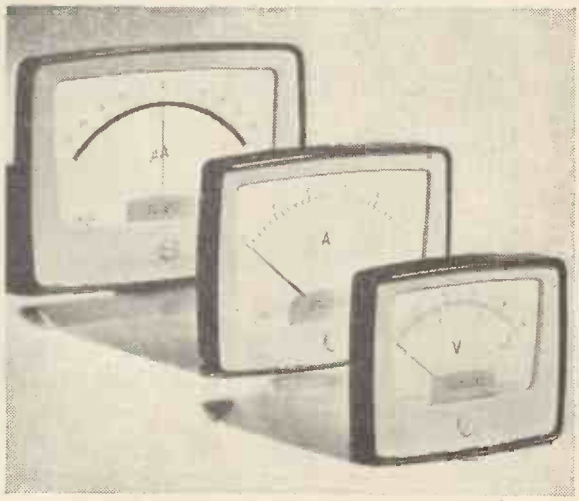

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MEDIUM AND LONG WAVE FULL TUNING

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CRYSTAL CONTROLLED OSCILLATORS: 10 Kc/s., 100 Kc/s. and 1 Mc/s. Output up to 20 Mc/s. On/Off MODULATOR. With handbook. Unused. ONLY 79/6. P.P. 2/6.

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From 6 Kc/s-47 Mc/s. FT243, FT241, 10XJ and B7G.
All types for all purposes.
Send for free list.

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Complete with 5 valves. In new condition. These Sets are sold without Guarantee, but are serviceable (7 to 9 Mc/s), 22/6. P.P. 2/6 Headphones 7/6 pair, Junction Box 2/6, Throat Mike 3/6, Aerial Rod 2/6.

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80/- P.P. 1/-. BASE 2/-

★★★ SPECIAL PURPOSE VALVES AND INDICATORS ★★★

805	35/-	803	35/-	1625	5/-	QS150/15	10/-	1B38	25/-	ACR10	35/-
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Free complete list on request. Bulk order enquiries invited.

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Limited Quantity of these Brand New and Guaranteed Instruments.

£15 P.P. 5/-

SPECIFICATION:
200/250 volt 50 c/s. supply or 4 volt 1 amp. dry cell.

SENSITIVITY (Typical) 32.5 mm./uA: 1.45 uV/mm. Period 2 secs: 850 ohms damping. Complete details supplied with each unit.

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- ★ 10-CHANNEL CRYSTAL CONTROLLED
- ★ 124.5 to 156 Mc/s COVERAGE
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COMPLETE UNIT WITH 21 VALVES, 24 VOLT POWER UNIT BUILT IN. INCLUDES CIRCUIT DIAGRAM, GOOD NEW CONDITION. LIMITED QUANTITY. ONLY £7/19/6. CARRIAGE 10/6.

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Complete with Valves, High Resistance Headphones. Handmike and instruction Book and circuit. Frequency Range 44.0 to 61 Mc/s. Range approximately 3 to 8 miles. Power requirements: Standard 120 v. H.T. and 2 v. L.T.
Ideal for Civil Defence and communications. BRAND NEW 44-61 Mc/s. Calibrated Wavemeter for same, 10/- extra.

45/- P.P. 5/-

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Acos 39-1 Stick Mic. with screened lead 39/6, P.P. 1/6
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AC/DC volts.
0-500 volts.
D.C. mA.
0-500 mA.
RESISTANCE
0-20 K.
COMPLETE WITH LEADS AND LEATHER CASE

79/6
P.P. 2/-
Limited quantity.

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(IDEAL FOR 'SCOPES)

2AP1	2in.	25/-
VCR139A	2¾in.	35/-
3BP1	3in.	30/-
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Mullard DG7/5	2¾in.	45/-
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VCR517C	6in.	30/-
VCR97	6in.	40/-
Screens for VCR97		7/6

P.P. 2/- any type.
ALL GUARANTEED.
FREE LIST and Data on request.

HENRY'S (Radio) LTD.

Opposite Edgware Road Tube Station. *PADdington 1008/9.*

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OPEN MONDAY to SAT. 9-6. THURS. 1 o'clock.

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6 ohm, small Colvern w/w	1/6 Each	10K + 10K American, ganged type J	2/6 Each
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400 ohm, 4 watt w/w	1/6 ,,	20K Colvern w/w	1/6 ,,
400 ohm, small Colvern w/w	1/6 ,,	½ meg. log. with s.p. switch	2/- ,,
1K miniature pre-set	1/3 ,,	50K Colvern w/w	1/9 ,,
2K w/w, for CR.100	2/6 ,,	75K Colvern precision, new and boxed	4/6 ,,
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3K miniature pre-set	1/3 ,,	500K miniature pre-set	1/9 ,,
3K American w/w, with switch	2/6 ,,	500K carbon	1/6 ,,
3K Burco w/w, instrument	1/6 ,,	1 meg. lin. with d.p. switch	2/6 ,,
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5K transistor pre-set	6d. ,,	2M miniature Deaf Aid	1/3 ,,
10K Colvern w/w	1/3 ,,		

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(Yaxley)		(Key)	Each
2p. 2w. Type A	2/6 Each	Ex. equipment	9d. ,,
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3p. 3w. with on/off switch	1/9 ,,	Sensitive press to make	2/6 ,,
4p. 3w.	1/9 ,,	Press to make with reset	2/6 ,,
D.P. c/o., intercom.	1/6 ,,	Press to make roller type	2/6 ,,
Ceramic)		B. & L. miniature protective:	
2 bank 2p. 3w.	2/6 ,,	0.2A and 0.4A with cut-out on overload	1/6 ,,
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POSTAGE AND PACKING on all the above—6d. except for Wheatstone Bridges 3/6 each.

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Now fitted with stainless steel guides—six times the life.

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Instantaneous to 5½ lbs.
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Full details of whole range by return.

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For Cathode Ray Tubes having Heater/Cathode short circuit and for C.R. Tubes with falling emission. Full instructions supplied.
Type A. Low Leakage windings. Optional Boost 25% and 50%. Tapped mains primaries:

2 volt	12/6 each
4 volt	12/6 each
6.3 volt	12/6 each
10.8 volt	12/6 each
13.3 volt	12/6 each

OUR LATEST SUPERIOR PRODUCT, Type A2. High Quality. Low capacity, 10/15 pf. Optional boost 25%, 50%, 75%. **16/6** each
Type B. Mains input. Low capacity. Multi Output 2, 4, 6.3, 10 and 13 volts. Optional boost 25% and 50%. Suitable for all Cathode Ray Tubes! 21/-.

RESISTORS. All preferred values. 20% 10 ohms to 10 meg., ¼ w., 4d.; ½ w., 4d.; 1 w., 6d.; 1½ w., 8d. 2 w. 1/-.
HIGH STABILITY. ½ w., 1%, 2/-. Preferred values 100Ω to 10 meg., Ditto 5% 9d., 100Ω to 5 meg.

WIRE-WOUND RESISTORS 25 ohms—10,000 ohms.

5 watt	1/3
10 watt	1/6
15 watt	2/-

15,000 ohms.—50,000 ohms, 5 w., 1/9; 10 w. 2/3

WIRE-WOUND POTS, 3 w. Pre-set Min. T.V. type Knurled Slotted knob, All values 25 ohms to 25K., 3/- ea., 30 K., 50 K., 4/-. Ditto, ½ w. Carbon Track 30 K. to 2 Meg., 3/-.

WIRE-WOUND POTS, 4 w. Standard size Pots, long Spindle High Grade. All values 100 ohms to 50 K., 6/6; 100 K. 7/6.

W/W EXT. SPEAKER CONTROL 10Ω, 3/-.

O/P TRANSFORMERS. Heavy duty 50 mA., 4/6. Multi-ratio push-pull, 7/6. Miniature 3V4, etc., 4/6. Hygrade Push-pull 10 watts, 15/6. Push-pull 20w. 6k or 8k 30/-
L.F. CHOKES 15/10H 60/65 mA., 5/-. 10H 85 mA., 10/6. 10H 150 mA., 14/-.

MAINS TRANSFORMERS 200/250 v. A.C.

STANDARD 250-0-250, 80 mA., 6.3 v. 3.5 a. tapped 4 v. 4 a. Rectifier 6.3 v. 1 a., tapped 5 v. or 4 v. 2 a. Ditto 350-0-350	22/6
MINIATURE 220 v. 20 mA., 6.3 v. 1 a.	10/6
MIDGET, 220 v. 45 mA., 6.3 v. 2 a.	15/6
SMALL, 200-0-200 50 mA. 6.3 v. 2 A.	17/6
STANDARD, 250-0-250, 65 mA., 6.3 v. 3.5 a.	17/6
HEATER TRANS., 6.3 v. 1½ a., 7/6; 3 amp.	10/6
GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 A.	22/6

ALADDIN FORMERS and cores, ¼in., 8d.; ⅜in., 10d. 0.3in. FORMERS 5937 or 8 and Cans TV1 or 2, ⅜in. sq. × 2¼in. or ⅜in. sq. × 1¾in., 2/- with cores.
SLOW MOTION DRIVES. Epicyclic ratio 6 : 1, 2/3.
SOLON. Midget Soldering Iron, 220/40 v. 25 w., 24/-.
REMPLOY INSTRUMENT IRON. 220/40 v. 25 w., 17/6.
MAINS DROPPERS. 3 × 1½in. Adj. Sliders, .3 amp. 1,000 ohms 4/3. .2 amps. 4/3. .1 amp. 2,000 ohms., 5/-.
LINE CORD. .3 amp., 60 ohms per foot, .2 amp., 100 ohms per foot, 2 way, 6d. per foot, 3 way 7d. per foot.

CRYSTAL MIKE INSERT by Acos 6/6

Precision engineered. Size only ⅞ × 1 1/16 in.
ACOS CRYSTAL STICK MIKE 39-1. Bargain 35/-.

MIKE TRANSF. 50 : 1, 3/9 ea.; 100 : 1 Potted 10/6.
LOUDSPEAKERS P.M. 3 OHM. 5in. Rola, 17/6. 6in. × 4in. Rola, 18/-. 7in. × 4in. R.A., 21/-. 10in. × 6in. Rola, 27/6. 8in. Plessey, 19/6. 6½in. Rola, 18/6. 8in. Rola, 21/-. 10in. R.A., 30/-.
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465 kc/s. slug tuning miniature can 2½ × 1 × 1in. High Q and good bandwidth. By Pye Radio. Data sheet supplied.
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2 p. 6-way, or 4 p. 2-way, or 4 p. 3-way, long spindle 3/6
3 p. 4-way, or 1 p. 12-way, long spindle 3/6
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MORSE KEYS, good quality, 2/6.
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Cascode circuit using Valve ECC84. 17db gain. Kit 29/6 less power; or 49/6 with power pack. Plans only 6d.
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"96" RANGE VALVES
KIT PRICE
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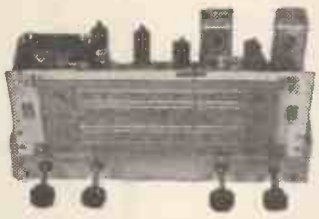

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Transidyne Superhet Six 6" × 4" × 1¾"
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Long spindle. Guaranteed 1 year. All values.
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32/450 v.	5/6	8+16/500 v.	5/6	32+32/450 v.	6/6
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100-250 volt A.C. input, 24 v. at 3 amps. or 12 v., twice at 3 amps. each winding. Continuous tropical rating switched and fused, etc., in metal case that fits 19in. rack, size 19 × 7 × 7in. Brand new £3/15/-, carr. 7/6 (with circuit).

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for the above power supply 2 chokes and 0-1 mA. meter (grade 1) metal case, same as the p.u., £2, carr. 7/6.

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(part of R20 6 Rec.), 115-600 kc/s, on three bands, large dial with a Mulrhead slow motion drive. Valves EP39, ARTH2, the set can be used with R107, R208, and many other types of receivers 32/6 each. Carr. 7/6.

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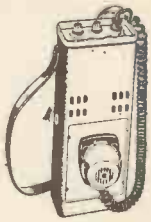

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RECORD PLAYER CABINET

R.P.8

79/9 cash OR **5/4** Initial payment

Balance at 3/11 a week for 19 weeks. This contemporary cabinet in two tone grey rexine is ideal for the modern home. Added attraction is the cream plastic speaker fret. Press button lid; lock. Fittings for screw in legs. Internal measurements 14½ x 18 x 8¾in. deep. Takes a Garrard 121 Mk. 2 or B.S.R. U12; 9½in. x 4½in. Elliptical speaker; our Mk. D.2 portable amplifier. Carr. & Ins. 5/6.

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17" T.V.s COMPLETE 19 gns.

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RECORD PLAYER CABINET

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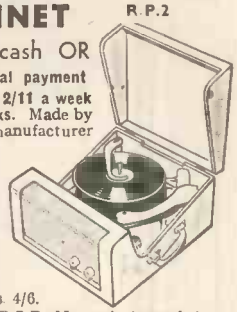
59/6 cash OR **4/1** initial payment

Balance at 2/11 a week for 19 weeks. Made by a famous manufacturer In polka dot cloth with clipped lid and carrying handle. Size 16in. x 14½in. x 8½in. deep.



Carr. & Ins. 4/6.

Will take B.S.R. Monarch 4-speed Autochanger, 7in. x 4in. elliptical speaker and our Mk. D.2. Portable Amplifier.

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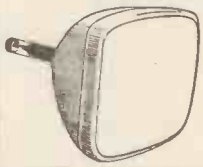

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12, 14, 15 in. TUBES £5.10.0 — **£1** allowed on old tube

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7 in. x 4 in. and 8 in. x 3 in.

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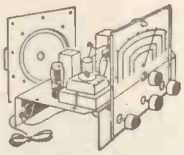
Five valve superhet chassis including 8in. P.M. Speaker and Valves. Four control knobs (tone, volume, tuning, w/change, switch). Four wavebands with position for gram. P.U. and extension speaker. A.C. Ins. & Carr. 5/6.

Cash Price 79/6



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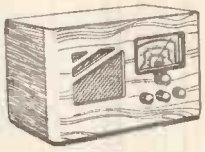
5 valve octal superhet. 3 waveband receiver. In attractive polished cabinet. Dimensions 9¾in. x 18½in. x 11¾in. Carr. & Ins. 4/6.



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Printed circuit. Latest design. Dimensions 7 x 2½ x 5in. A.C. only. Mains isolated. 4 watts output. Incorporating the latest ECL82 triode pentode output valve, giving high undistorted output. Volume and tone controls. Knobs 2/6 extra. P. & P. 3/6.

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As D.2. but with 3 controls, incorporating a special tone corrector circuit for extra base and top boost, giving a tone of reproduction seldom heard on a very expensive amplifier. Must be heard to be appreciate. Knobs 3/6. P. & P. 3/6.

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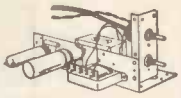

Brand new. Latest design with printed circuit. Dimensions 7 x 2½ x 5in. A.C. only. Mains isolated 3 watts output. Incorporating EL84 as high gain output valve. Volume and tone controls. Knobs 2/6 extra. P. & P. 3/6.

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T.U.9 B.S.R. 4-speed single player	£4	9	6
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Compact well designed 5 valve amplifier. Output 3.5 watts. Valve line-up ECC83. Double triode first audio amplifiers. ECL82 Triode pentode further audio amplifier and output valve. 6BW6 Dias and erase oscillator. EM84 Record Level Indicator. EZ80 H.T. rectifier. Input for mike, radio and gram. Controls—Record Playback volume and On/Off Playback tone. Dia.: 8½in. x 3in. x 4¾in. Ins. and carr. 4/6. Initial payment 9/1 plus Ins. and Carr. 19 weekly payments of 7/11.

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Famous manufacturer. Huge purchase allows us to offer at this amazing price. Beautifully styled, rexine covered cabinets. Colours: Red, Grey, Black. Storage space for 4 tapes, mike and lead. Incorporating the latest B.S.R. Deck. LOOK AT THESE EXPENSIVE FEATURES. Controls. Record/Playback switch and rewind with interlocking device to prevent accidental erasure. Tone and volume controls. Superimpose and electronic eye. Ample power output 3.5 watts. Small overall size 14½in. x 14½in. x 7½in. Lightweight, only 21 lbs. Playing time 1½ hours. 5¾in. standard tape. Terms. Carr. and Ins. 12/6. Microphone 27/6 extra. Tapes 19/9.

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WITH EXTENSION SPEAKER CABINET AT THE AMAZING OFFER OF 99/6

Portable 1960 Show Model in two tone colours. Extension speaker cabinet secured in lid. Size 18in. x 14in. x 8½in. high. This stereophonic player complete, retails at 35 gns. in the shops today. Ins. & Carr. (with order) 5/6, or initial payment plus Ins. & Carr. of 6/1 and 19 weekly payments of 4/11.

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ONLY 35/- The **"CORONET"** 2-transistor radio. Is very sensitive—ideal for Office, Bedroom, Holidays, etc. Fits in the palm of your hand. Months' and months' listening off a 7d. battery. **CAN BE BUILT FOR ONLY 35/-,** including everything down to the last nut and bolt and our **SIMPLE CONSTRUCTION ENVELOPE** makes it easy as A, B, C. Post and packing 2/- extra. (C.O.D. 2/6 extra.) (Parts sold separately. Components price list 1/-.)

THE LATEST B.S.R. TAPE DECK, brand new and boxed. **OUR PRICE £9/19/6.** P. & P. 4/6.
RED-SPOT TRANSISTORS, tested, 5/- each. **WHITE-SPOT TRANSISTORS,** tested, 7/6 each.
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ONLY 97/6 The famous **"CABY" TESTMETER.** We recommend these multi-range meters as being accurate and well made. Ranges cover A.C., D.C. and resistance. New in box with test prods and instructional booklet. **OUR PRICE 97/6.** P. & P. 2/6.

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Wired and tested, 17/6 extra.

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- 6v. operation (2 E/R Type 800 batts.)
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(8 Units) only **£7.19.6** Carr. 3/6.
Circuit diagram, full technical spec. and constructional details (free with kit), 2/6 post free.

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Colour: Two-tone Red/White with Polka Dot relief. Alternative Blue/Fawn with Polka Dot relief.

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Contemporary style, rexine covered cabinet in fawn and brown with cream interior. Size 18½ x 13½ x ht. 8½in., fitted with all accessories including baffle board and anodised metal fret. Space available for all modern amplifiers and autochangers, etc. Uncut record player mounting board 14 x 13in. supplied.

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Twin stage ECL82 with vol. and neg. feedback Tone control. AC 200/250 v. with double-wound Mains trans. Complete with knobs, etc., ready wired to fit above cabinet.

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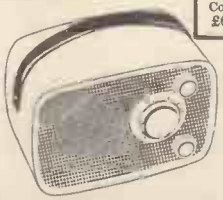

Size only 8in. x 5½in. x 4in.

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Set 4 miniature valves (96 series).....	35/-	P. & P. 9d.
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Cabinet, Dial & Knobs, etc.	22/6	P. & P. 2/-

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Complete Kit *post free* **£6.10.0**

Latest circuitry delayed AVC & A.F. Neg. feedback.
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5Z4	9/6	ECH42	10/6	PCF80	9/6
6K7	5/6	ECL80	10/6	PCL83	12/6
6K8	8/6	EF80	8/-	PL81	12/6
6Q7	8/6	EF86	12/6	PL82	9/6
6V6	7/6	EF91	7/6	PL83	10/6
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DF96	9/-	EL84	8/6	PY81	9/6
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SPECIAL PRICE PER SET
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RESISTORS—FULL RANGE 10 ohms—10 megohms 20%, ¼ w. and ½ w. 3d., ¾ w. 5d. (Midget type modern rating), 1 w. 6d., 2 w. 9d., 10% Hi-Stab, ¼ w., 5d., ½ w., 7d., 5% ½ w., 9d., 1% HI-STAB, ½ w., 1/6 (10-100 ohms 2/-).

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Comprehensive range in stock.

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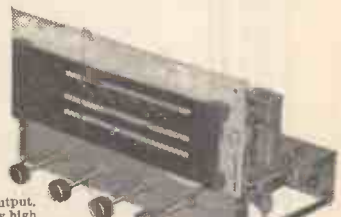
7 VALVE AM/FM RADIOGRAM CHASSIS

Valve Line-up: ECC85, ECH81, EF89, EABC80, EL84, EM81, EZ80.



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Aligned and tested ready for use. **£13 . 10 . 0** *Carr. & Ins. 5/-*

Complete with 4 Knobs—walnut or ivory to choice.
Three ohm P.M. speaker only required. Recommended quality speakers.

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10in. Rola (Heavy Duty)	30/-

Post & Pkg. 1/6.

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2 WAVEBAND CAR RADIO KIT

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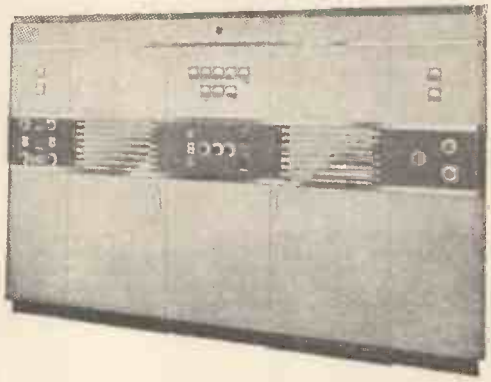
Enclosure	11ft.	7ft. 6ins.	4ft. 1in.
Rectifier Unit	4ft. 2ins.	5ft. 3ins.	3ft. 2ins.
Plate Transformer	2ft. 6¾ins.	3ft. 6⅜ins.	1ft. 9½ins.

Weight (Nett)	
Enclosure (including control, R.F. and Output panels)	3,000 lbs.
Rectifier Unit	1,675 lbs.
Plate Transformer 7,000 volts	1,250 lbs.



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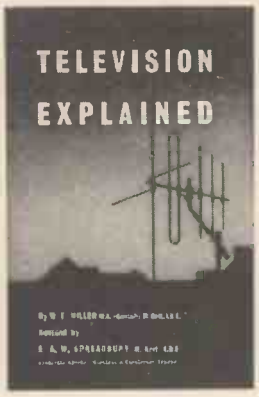

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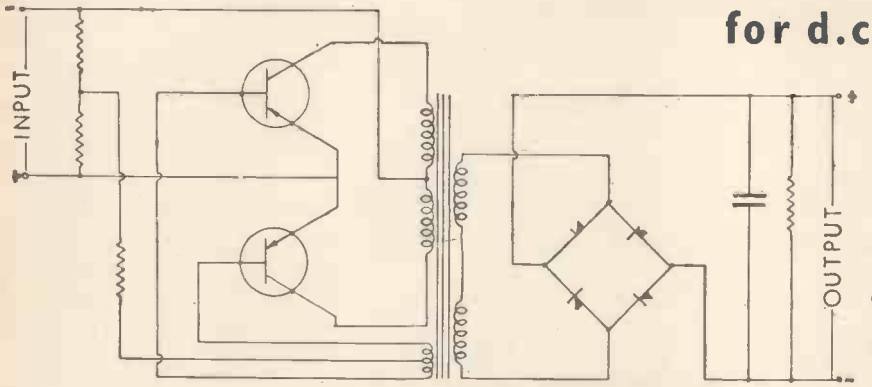

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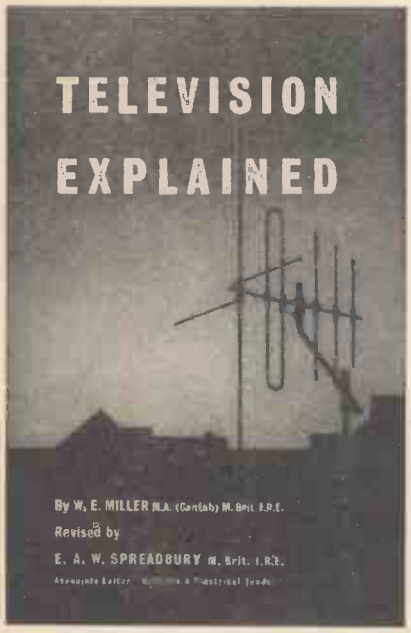

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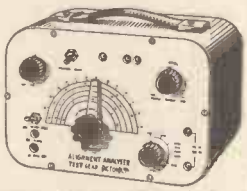

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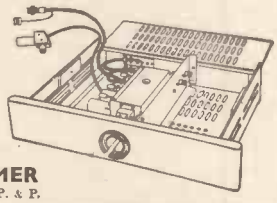

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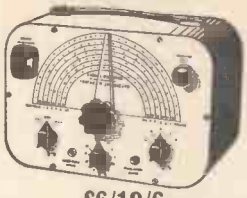

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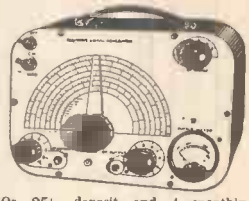

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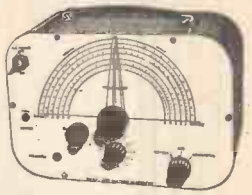

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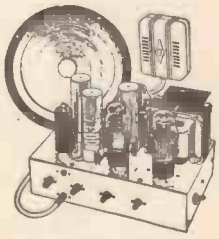

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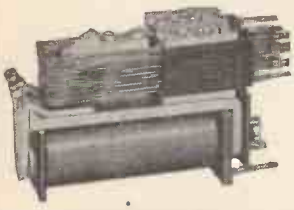

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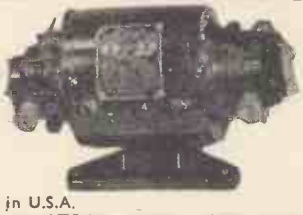

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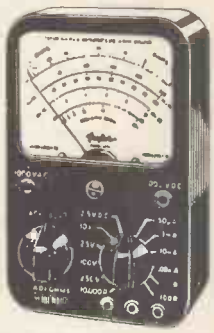

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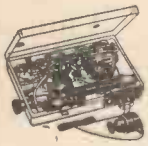

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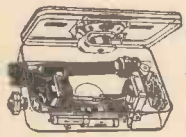

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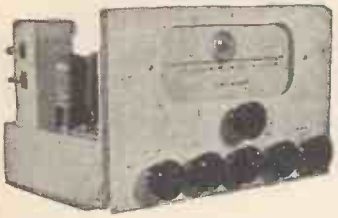

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BRITISH INSTITUTE OF ENGINEERING TECHNOLOGY *(Incorporating E.M.I. Institutes)* **(Dept. SE/22), 29 Wright's Lane, London, W.8**

THE B.I.E.T. IS THE LEADING ORGANISATION OF ITS KIND IN THE WORLD

THE DATA PROCESSING AND CONTROL SYSTEMS DIVISION OF THE

ENGLISH ELECTRIC

COMPANY LIMITED

has vacancies for a number of

SITE COMPUTER ENGINEERS

for diagnosis of logic and circuitry faults at Operational Establishments in the Home Counties and Preston, Lancashire. Successful applicants will, after an initial training course, be required to take up responsible positions at Computer Installations on customers' premises.

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1. An Engineer for permanent night duties. In view of the special operating circumstances of the Computers concerned, this Engineer will be required to work 9.30 p.m. to 8 a.m. four nights a week and will receive an appropriate salary.
2. An Engineer primarily engaged for daytime duties.

Applicants for any of the above positions should hold a Higher National Certificate (or equivalent qualifications) and have had at least two years experience in Development or Maintenance of Computers or other pulse circuitry.

During training, special subsistence allowance will be made to any successful applicants, who have to live away from home. Attractive salaries will be offered with these positions, which are permanent and enjoy the benefits of the Company's attractive Staff Pensions Scheme and qualify, after initial service, for three weeks annual holiday. Assistance with housing may be available in certain cases.

Applications should be made in writing, giving full details of qualifications and experience to: Dept. G.P.S., Marconi House, Strand, W.C.2, quoting reference WW 388B.

ELECTRONIC MAINTENANCE TECHNICIANS

are required by the

ENGLISH ELECTRIC VALVE COMPANY LTD.,
Chelmsford Essex

They should possess maintenance experience on radar or radio installations for work on modulators for the testing of magnetrons.

Attractive salaries and conditions of employment can be offered to suitable applicants.

Applications should be made to the:

Personnel Officer Dept. G.P.S., Marconi House, Strand, London, W.C.2
quoting reference W.W. 1590C.

COUNTY BOROUGH OF BOLTON - EDUCATION DEPARTMENT

BOLTON TECHNICAL COLLEGE

FULL-TIME ELECTRONIC ENGINEERING COURSE

A three year course in Electronic Engineering is available. Candidates should be at least 16 years of age and have taken, or be taking, General Certificate of Education courses, which include Mathematics and Physics at the Ordinary and/or Advanced level, or equivalent courses in Technical Institutions. The Institution of Electrical Engineers accepts the College Diploma for exemption from Parts I and II of the Institution Examination.

This rapidly developing industry offers new and attractive openings to qualified men, and students who have passed through the course are readily absorbed by industry.

Further particulars may be obtained from the Principal.

MARCONI INSTRUMENTS

ST. ALBANS HERTS.

Junior and Senior Design Development Engineers required for work on Electronic Measuring Instruments in the Telecommunication field. Applicants should have a sound knowledge of Radio Frequency work and also experience in the use of electronic test gear associated with this type of Design Work. These Engineers would work in a small team which is responsible for a new design from the specification stage right through to the ultimate production. The positions are permanent and pensionable and offer good prospects to suitable men.

Write to **Dept. G.P.S., Marconi House, Strand, London, W.C.2** quoting reference WW 2970S.

TECHNICAL TRAINING in radio television and electronics engineering with

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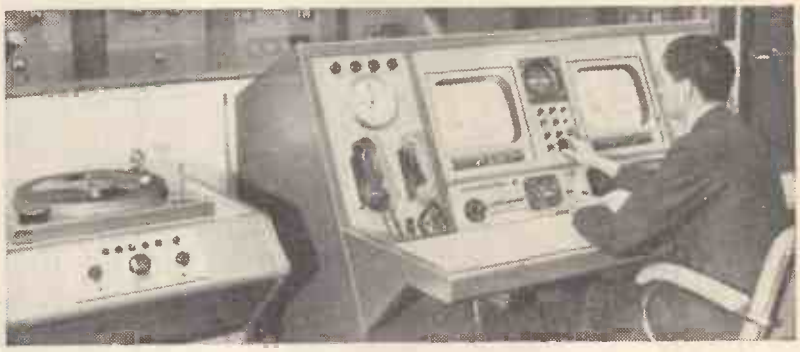
Gain a sound knowledge of Radio and T.V. as you build YOUR OWN 4-VALVE T.R.F. and 5-valve superhet radio receiver, Signal Generator and High-quality Multi-tester. At the end of the course you have three pieces of permanent and practical equipment and a fund of personal knowledge and skill . . . ICS Practical Radio courses open a new world to the keen Radio amateur.



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You will receive the FREE 60-page ICS Prospectus listing examinations and ICS technical courses in radio, television and electronics PLUS details of over 150 specialised subjects.

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INITIATING NEW DESIGNS FOR COMPUTER SYSTEMS

being encouraged?

It will be at I.C.T.! We are looking for men who have proved their ability on the logical design of computers or similar digital equipment.

We are offering you the opportunity to join our rapidly expanding research team where you can take responsibility for the initial design of large scale equipment.

You would enjoy a generous salary, excellent amenities and pension scheme facilities. You would hold a key position in our well equipped Electronic Laboratories at Stevenage, where housing aid is available.

We expect you to have an Honours Degree. But proven experience, ability and 'flair' can override its necessity.

Similar posts are available in our Special Projects Department at Dartford, Kent

I·C·T

Write to:
Manager, Personnel and Training Division

International Computers and Tabulators Limited

Gloucester House, 149 Park Lane, London, W1

ENGLISH ELECTRIC VALVE COMPANY LTD.

COMMERCIAL ENGINEERS

Two new positions exist in our Sales Engineering Division for experienced electrical or electronic engineers with several years in sales engineering in the electronics industry.

Applicants should possess sound knowledge of transmitter valves, microwave tubes, and their applications.

An engineering degree and/or qualifications to C.I.E.E. standard required.

These are permanent, pensionable positions in an expanding industry. Write in first instance with details of age, experience and qualifications to

Group Personnel Officer,
Marconi House, Strand, London, W.C.2,
quoting reference W.W. 15973.

RADIO POLICE

INSPECTORS OF POLICE (SIGNALS)
required by
GOVERNMENT OF NYASALAND

for permanent and pensionable appointments subject to satisfactory probationary service.

Commencing salary based on age and experience in scale £760 rising to £1,285 a year. Initial outfit grant and annual uniform allowance. Free passages. Liberal leave on full salary.

Candidates of good education and physique, not below 5ft. 7in., normal vision without glasses, must have sound knowledge of H.F. and V.H.F. fixed and mobile simplex and duplex radio telephone systems and low power petrol/electricity chargers and alternators. Knowledge of morse and ability to instruct trainees on radio subjects an advantage. Preference given to candidates under 30 years of age.

Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, qualifications and experience and quote M2A/50901/WF.

LOUGHBOROUGH COLLEGE of TECHNOLOGY INSTRUMENTATION

A One-year post-graduate course in Instrumentation, organised in three substantially independent terms of ten weeks duration each, is being offered at Loughborough College of Technology.

The content of the course has been planned to provide a good grounding in the fundamentals of industrial measurement techniques with particular emphasis on Instrumentation for Control Engineering.

Tuition fees—£25 per term
£75 full course

College Union Fee—£2 per term.

Residential accommodation will be available in one of the College halls.

Further particulars can be obtained from:—
Head of Department of Electrical Engineering,
Loughborough College of Technology,
Loughborough, Leicestershire.

THE INDEPENDENT TELEVISION AUTHORITY

invites applications for the appointment of Assistant Engineer in Charge at each of its Medium Power Transmitting Stations which are now being built at Caradon Hill, Liskeard, Cornwall, and Stockland Hill, Honiton, Devon. The successful applicant would be required to control a shift and to act as deputy to the Engineer in Charge. He must have a first class knowledge of high frequency and television engineering, with practical experience in the operation and maintenance of television transmitters, and ancillary equipment. The salary scale for this appointment is £1,090 x £100—£1,390 x £95—£1,580. Applications quoting E/16 and stating age, experience, qualifications should be addressed to the

Personnel Officer,
I.T.A.,
62, Brompton Road,
London, S.W.3.

Not later than August 1, 1960.

DRAUGHTSMEN

Opportunities exist for CIRCUIT and ELECTRO-MECHANICAL DRAUGHTSMEN to obtain progressive positions on interesting new projects. Convenient interviews arranged by telephone (DERwent 6688), or apply:-

Personnel Officer
DECCA RADAR LIMITED,
2 Tolworth Rise,
Surbiton, Surrey.

Plessey

Radio and Television
Advanced Development Laboratories

The Radio and Television Division of the Equipment Group is opening a new Laboratory at the **West Leigh Advanced Development Centre.** West Leigh is situated on the South Coast between Portsmouth and Chichester in pleasant rural surroundings.

This new Laboratory, which will open shortly, requires

DEVELOPMENT ENGINEERS

preferably experienced in modern radio and television design, but full consideration will be given to those suitably qualified whose experience has not embraced this field.

All grades of engineers are required and in these positions there is every opportunity for real ability to be recognised, resulting in rapid promotion in this expanding organisation.

If you would like to learn more about these opportunities, the Chief Engineer of the Division would be pleased to discuss them either at West Leigh, or, if preferred, in London. For engineers wishing to be nearer London, similar vacancies exist in the Radio and Television Laboratories at Ilford, Essex.

Replies, which will be treated in complete confidence, should be addressed to:—

The Personnel Manager, THE PLESSEY COMPANY LTD.,
West Leigh, Bartons Road, Havant, Hants.,
Quoting ref. DE/622/WW

TELEVISION RECEIVING EQUIPMENT

4TH EDITION

by W. T. Cocking M.I.E.E.

The book deals comprehensively with television receiving equipment and gives many practical details and design data. It assumes that the reader will have a fair knowledge of sound radio technique, and while the treatment is largely non-mathematical formulæ useful to the designer have been collected in appendices

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G.E.C.

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Vacancies have arisen in the development and pre-production fields of microwave and thermionic valve manufacture at:—

M-O VALVE COMPANY LIMITED

(A subsidiary of G.E.C.)

Spheres of interest to Physicists, or Electronic or Mechanical Engineers will be available and a four-figure salary will be payable to successful candidates, according to qualifications and experience.

Applications are invited from Physicists, qualified Electronic or Mechanical Engineers, preferably aged between 24 and 40 years, to:—

Personnel Manager Ref. PM/DE/60
M.O. VALVE CO. LTD.,
Brook Green, Hammersmith, W.6.

Strictest confidence will be observed.

UNICAM INSTRUMENTS LTD.

This company specialises in the production of high quality optical instruments for use in spectrum analysis and has an international reputation as a leader in this field. At all stages of manufacture the best standards of workmanship are needed.

We have vacancies for men with electronic experience for testing. Radar and radio technicians with fault finding experience would be suitable.

If you have the kind of background which you think would fit you for this interesting work in a pleasant University City, please let us have full details of your qualifications and experience.

Write to:—

The Works Manager,
Unicam Instruments Ltd.,
Arbury Works, Cambridge
quoting reference E.S.26.

RADIO TECHNICIANS IN CIVIL AVIATION

Men aged 19 or over for interesting work providing and maintaining aeronautical telecommunications and electronic navigational aids at aerodromes and radio stations in the U.K. Fundamental knowledge of radio or radar with some practical experience essential; training provided on special types of equipment. Salary according to age and station, approx. £670 at age 25 rising to £795. Prospects of permanent pensionable posts. Good opportunities for those who obtain O.N.C. in Elec. Eng. and certain C. and G. Certificates for promotion to posts with maximum salaries of £875, £1,035 and £1,260. Apply to the Ministry of Aviation (ESB1/RT), Berkeley Square House, London, W.1, or to any Employment Exchange (quoting Order No. Westminster 3552).

ELECTRONIC ENGINEERS and TECHNICIANS

are required by old-established engineering firm in North Cheshire to join new service department being formed in order to introduce specialised computing equipment of American design into Europe.

ENGINEERS must possess H.N.C. or equivalent with not less than two years experience in pulse circuitry and techniques. Salary in terms of experience.

TECHNICIANS must possess O.N.C. with not less than two years experience in the electronic industry. Salary in terms of experience.

All applicants must be free of military service obligations. Please write, giving details of age, education, experience, etc. to Box No. 369 c/o "Wireless World."

THE UNITED OXFORD HOSPITALS

Applications are invited for the post of Chief Electronics technician to assist in the developments related to cardiac surgery. The salary will be £785 to £1,005 (subject to review). Conditions of service will be in accordance with the Whitley Council for the National Health Service. Applications together with the names of two referees should be addressed to the Assistant Administrator, Radcliffe Infirmary, Oxford, from whom further particulars may be obtained.

VACANCIES IN GOVERNMENT SERVICE

A number of vacancies offering good career prospects, exist for:—

RADIO OPERATORS — MALE
CYPHER OPERATORS } MALE &
TELEPRINTER OPERATORS } FEMALE

Write giving details of Education, Qualifications and Experience to:—
Personnel Officer,
G.C.H.Q. (FOREIGN OFFICE)(3/R CO),
53, Clarence Street, Cheltenham, Glos.

Ferranti —EDINBURGH

TRIALS ENGINEER

Ferranti Limited wish to recruit a trials engineer to join a team on the development trials of an advanced radar fire control system. Applicants should have a degree or Higher National Certificate and about three years experience in the electronic field. The successful candidate must be prepared to fly in modern high speed aircraft. A staff position with membership of a pension scheme and a substantial salary will be offered. Please apply giving details of training and experience to the **PERSONNEL OFFICER, FERRANTI LIMITED, FERRY ROAD, EDINBURGH, 5 quoting Ref. Tr. E/59.**

Battersea College of Technology, London, S.W. 11. (Physics Dept.)

The following Postgraduate Courses will be held during the Session 1960-61. Autumn Term begins October 3rd, 1960.

1. **Microwave Physics** (full-time and part-time) leading to M.Sc. The Department of Industrial and Scientific Research has accepted this course as suitable for tenure of its Advanced Course Studentships.
2. **Radiation Physics and Radiological Protection** (part-time and evening), leading to the Certificate of the College.
3. **Rheological Techniques** (evenings).

Full details and enrolment forms from the Head of Department.

We do not want you to apply...

to us if you want a routine job.

On the other hand if you want an EXCITING, VIRILE position in Britain's latest industry with considerable opportunities of improvement we will be very pleased to hear from you.

Current vacancies located in a pleasant part of the country about an hour's journey north of London are as follows:—

Chief Applications Engineer

An energetic and competent man is wanted to lead a growing team of engineers engaged in applying Company products to the needs of the customer.

The field covered is wide and includes new types of magnetic material, ceramics, loaded rubbers, etc., for the electronic and telecommunication industry.

The work is challenging and at times exciting but the right man can make it fascinating and rewarding.

A good degree or professional status in physics, electrical or electronic engineering is desirable, but extensive practical experience and administrative ability are essential.

Development Engineer for the development and testing of electronic components. A knowledge of electrolytic Capacitors or semi-conductor devices would be advantageous. H.N.C. level preferred.

Technical Assistants for the servicing and modification of electronic test and control equipment. Ordinary National Certificate or better is preferred and a knowledge of pyrometry as applied to the control of kiln temperatures is required for one vacancy.

Prototype Wiremen for the construction of automatic test and production equipment. All vacancies are permanent and progressive. There is an excellent contributory superannuation scheme. Housing at all levels is readily available.

Apply in confidence to Box No. 0585 c/o "Wireless World".

T.V. ENGINEER

required, fully experienced. Top wages. Permanent position.

RITZ RADIO

306 NEASDEN LANE, N.W.10

GLADSTONE 4983

EMI

Interesting vacancies exist at the Feltham Laboratories of E.M.I. Electronics, Ltd., for the following:

ENGINEER to be responsible for the climatic testing of components and equipment. The post involves liaison duties with associated project teams. A H.N.C. in Electrical Engineering, together with experience in the basic techniques of measurement applicable to electronic components is an essential qualification for this post. Experience of environmental testing, particularly with regard to G.W. work would be a decided advantage. Ref. Sa/2/4

TRANSFORMER DESIGNER (TEAM LEADER)—An experienced Transformer Designer of special purpose Transformers for use in G.W. and other defence projects is required. The qualifications required are H.N.C. and an imaginative engineering outlook, together with a sound theoretical and practical knowledge of Transformer design. Several years' experience in this field is essential. Ref. Sa/2/5

INTERMEDIATE VALVE LIAISON ENGINEER in a group advising on the availability and use of valves and semi-conductors for missile borne "radar" applications. The Engineer appointed will be deputy to the head of section and will be required to organise trials on valves and semi-conductors and to give technical advice. A degree or H.N.C. with relevant experience is essential. Ref. Sa/12/6

ENGINEER to carry out the maintenance, modification and calibration of testing equipment to A.I.D. standard. Candidates should have at least two years' experience of this work and also hold qualifications up to H.N.C. (Electrical Engineering) standard. Ref. Aa/8/x

TECHNICAL ASSISTANT to assist an Engineer in the carrying out of the work detailed above. Experience in the servicing of test gear, either in the Armed Services or Industry is essential. An O.N.C. (Electrical Engineering) would be a distinct advantage. Ref Aa/8/x

ENGINEER to join a project team and to be responsible for carrying out liaison duties between that team and other internal departments. He would also ensure that equipment designed is compatible with customer requirements. Candidates should hold a H.N.C. in Electrical Engineering and have a minimum of three years' experience in electronic development work. This post would be of interest to a young engineer wishing to take on duties with an appreciable administrative content. Ref. Pa/4/30

Starting salaries will be determined by qualifications and experience and it is Company practice to review salaries annually on the basis of ability and potential.

Please write, quoting the appropriate reference number, to:

Personnel Manager,
E.M.I. ELECTRONICS LTD., HAYES, MIDDLESEX.

ENGINEERS & SCIENTISTS

of professional standing who wish to explore the possibilities of a new appointment are invited to write for further information regarding this confidential service covering the whole of Great Britain to

STAFF CONSULTANTS LIMITED

Engineering & Scientific Personnel Consultants,
20, Southampton Place, London, W.C.1.

PHILIPS ELECTRICAL LIMITED

(Medical X-ray Division)
45 Nightingale Lane,
Balham, S.W.12.

A vacancy has arisen for an Assistant in the Installation Planning Department. Knowledge of electronics and drawing office experience desirable. Capable of working on own initiative, training will be given. Aged 18/23. Write giving full details of experience etc. to the Personnel Officer, at the above address.

SMITHS Radiomobile

BRITAIN'S CAR RADIO SPECIALISTS INVITE APPLICATIONS FOR THESE POSTS

ASSISTANT FOREMAN

Experience of car radio application and maintenance desirable but not absolutely essential. This progressive appointment is in the Service Department.

EXPERIENCED SERVICE ENGINEERS

These appointments hold out very definite prospects of advancement for the right individuals.

Applications giving full details of career to date should be addressed to:
THE STAFF MANAGER, S. SMITH & SONS (ENGLAND) LTD., CRICKLEWOOD, LONDON, N.W.2 quoting ref. SM245

London County Council Norwood Technical College

Applications invited for the following posts in department of Telecommunications and Electronics which provides full-time courses in Telecoms, Electronics, Radio Operating and Radar; part-time courses additionally include Radio and T.V. Servicing, T.V. Technology and other specialist subjects.

Assistants grade B to teach:—

(i) Radio and Electronics in full- or part-time courses leading to B.I.R.E. and C. & G. exams.

(ii) Radio Operating and Radar in P.M.G. and M.O.T. Radar Certificate courses. Special knowledge of and qualifications in one or both these subjects necessary.

(iii) Machine Shop and Workshop Practice and Engineering Drawing in full- and part-time courses leading to C. & G. and G.C.E. exams.

(iv) Radio, T.V. and Electronic Servicing in courses leading to C. & G. and R.T.E.B. exams.

Burnham (FE) salaries in the range £738-£1,486. Commencing and maximum salary depending on age, qualifications and experience. Appointments temporary in first instance.

Application forms from Principal at College (FE3a/WW/1626/8), Knights Hill, S.E.27.

Senior Electronic Engineer

A vacancy exists for a senior engineer to work on the development of new types of nuclear electronic equipment. Applicants should be of graduate status or equivalent, with several years experience of electronic development, preferably including recent work on semi-conductor units. Commencing salary not less than £1,000 p.a., according to qualifications and experience.

Apply in confidence to:—
The Personnel Manager, Plessey Nucleonics Ltd., Weedon Road, Northampton.

CONTROL
SAUNDERS-ROE LIMITED
a Division of
Westland Aircraft Limited

have vacancies for CONTROL ENGINEERS to work on the Trials and further development of "Black Knight" at High Down, Isle of Wight. There is also a vacancy for a Mechanical Engineer with Rocket Motor experience. Applicants should forward details of their career to date to the:
Personnel Officer, SAUNDERS-ROE LIMITED, East Cowes, Isle of Wight.
Quoting reference DT.62.

INDEPENDENT TELEVISION NEWS LIMITED

require

CAMERAMAN / TECHNICAL ASSISTANTS and OPERATOR/ENGINEERS to operate camera and electronic equipment during transmission time and act as Technical Assistants or Engineers outside transmission periods, constructing and maintaining equipment with the minimum of supervision. Sound knowledge of electronic theory with practical experience required. Junior development engineer in radio or electronics would be suitable for the junior positions. Minimum salaries £1,023 or £1,292 per annum according to experience. Applications in writing to the Secretary, I.T.N., **Television House, Kingsway, W.C.2.**

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

Instrument Mechanics (Physical and Electronic) and Instrument Electricians

We have vacancies for men experienced in fault diagnosis, repair and calibration of a wide range of instruments used in nuclear reactors, radiation laboratories and chemical plant operation. The work is interesting and involves working with instruments using pulse techniques, wide band low noise amplifiers, pulse amplitude analysers, counting circuits, television, and industrial instruments for the measurement of flow, pressure and temperature.

Men with appropriate experience in H.M. Forces or with industrial experience of radar, television, radio or industrial instrumentation are invited to write for further information.

The rate of pay is £12.12.0d. for a 44-hour, 5-day week. Housing will be available for married men. Promotion prospects are good and there is a superannuation scheme.

Application forms and further information can be obtained from:

Recruitment Officer, Dounreay Experimental Reactor Establishment, Thurso, Caithness, Scotland.

W. H. ALLEN SONS & COMPANY LTD.

require a

SENIOR ELECTRONICS ENGINEER

for their Servomechanism Design Department for work on electronic instruments and control systems.

Applicants, age about 30, should have an Honours Degree in Electrical Engineering or alternatively an H.N.C. with a wide experience would be acceptable. Considerable design experience of transistor circuitry and digital techniques is essential and a sound knowledge of servo theory would be advantageous. The work involves co-operation with other staff working on electro-mechanical and hydraulic systems. The above post offers good prospects, excellent conditions of service, and a Contributory Pension and Life Assurance scheme. A comprehensive range of Welfare and Recreational facilities is available and assistance will be given towards expenses involved in moving and settling in the district.

Applications should be made in writing, giving details of age, qualifications, experience and present salary to:
THE PERSONNEL MANAGER (Ref. 1001/4) QUEENS ENGINEERING WORKS, BEDFORD

THE INDEPENDENT TELEVISION AUTHORITY

invites applications for the appointment of Engineer-in-Charge at its Medium Power Transmitting Station which is now being built at Caldbeck, near Carlisle. Applicants must have Electronic qualifications, a first-class knowledge of High Frequency and of Television Engineering, and must have gained practical experience of the detailed organisation and operation of a Television Transmitting Station. The successful applicant may be posted to one of the Authority's existing transmitting stations, prior to taking up his permanent appointment at Caldbeck early next year. The scale for the post of £1,190–£1,920 per annum. A contributory Pension Scheme is in operation. Applications, stating age, experience and qualifications, should be addressed to the

Personnel Officer, I.T.A., 62, Brompton Road, London, S.W.3, quoting reference E/18, not later than 8th August.

AMPLIFIER DEVELOPMENT

Engineer required to assist design and development of large electronic power amplifiers and associate equipment. Applicants preferably educated to degree or H.N.C. standard. Write to Manager, Vibration Department, W. Bryan Savage Ltd., 8, Dalston Gardens, Stanmore, Middx., giving details of qualifications and experience.

THE INDEPENDENT TELEVISION AUTHORITY

invites applications for the appointment of Assistant Engineer-in-Charge at its Medium Power Transmitting Station which is now being built at Caldbeck, near Carlisle. The successful applicant would be required to control a shift and to act as deputy to the Engineer-in-Charge. He must have a first-class knowledge of high frequency and television engineering, with practical experience in the operation and maintenance of television transmitters, and ancillary equipment. The salary scale for this appointment of £1,090 × £100—£1,390 × £95—£1,580. Applications quoting E/19 and stating age, experience, qualifications should be addressed to the **Personnel Officer, I.T.A., 62, Brompton Road, London, S.W.3,** not later than the 8th August, 1960.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

PRODUCTION GROUP

INSTRUMENT MECHANICS

Windscale and Calder Works, and Chapelcross Works require experienced men with knowledge of electronic equipment and/or industrial instrumentation for fault diagnosis, repair and calibration of a wide range of instruments used in nuclear reactors, radiation laboratories and chemical plant. This interesting work involves the maintenance of instruments using pulse techniques, wide band low noise amplifiers, pulse amplitude analysers, counting circuits, television and industrial instruments used for the measurement of pressure, temperature and flow.

Men with Services, Industrial or Commercial background of radar, radio, television, industrial or aircraft instruments are invited to write for further information. Training Courses in Specialised Techniques are provided for successful applicants having suitable Instrumentation background.

Married men living beyond daily travelling distance will be eligible for housing. A lodging allowance is payable whilst waiting for housing. Working conditions and promotion prospects are good.

Applications to:

Works Labour Manager, Windscale and Calder Works, Sellafield, Seascale, Cumberland

or

Works Labour Manager, Chapelcross Works, Annan, Dumfriesshire, Scotland.

Telecommunications Equipment

DEVELOPMENT ENGINEERS

SENIOR & JUNIOR ENGINEERS

Required for the following posts

AIR/SEA RESCUE EQUIPMENT

LIGHT AIRCRAFT MULTI CHANNEL EQUIPMENT

HOMING DEVICES

—

Applicants should have previous experience in V.H.F. and U.H.F. Equipment, also a good working knowledge of transistor techniques.

Posts carry good salaries, excellent working conditions and first class prospects of advancement.

Write in confidence, giving full details of age, experience and qualifications, to

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Tel.: AMBassador 0151/2 **Cables: ZAERO, LONDON**

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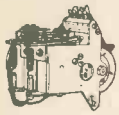

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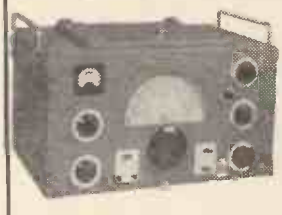

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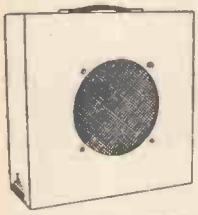

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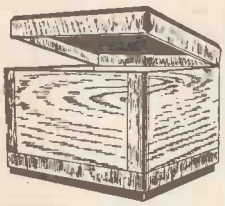

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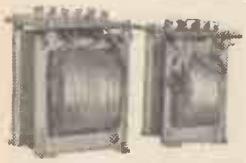

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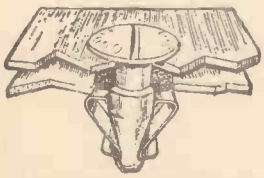

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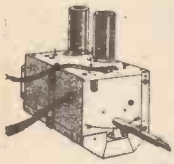

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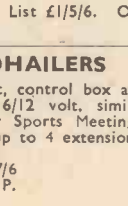

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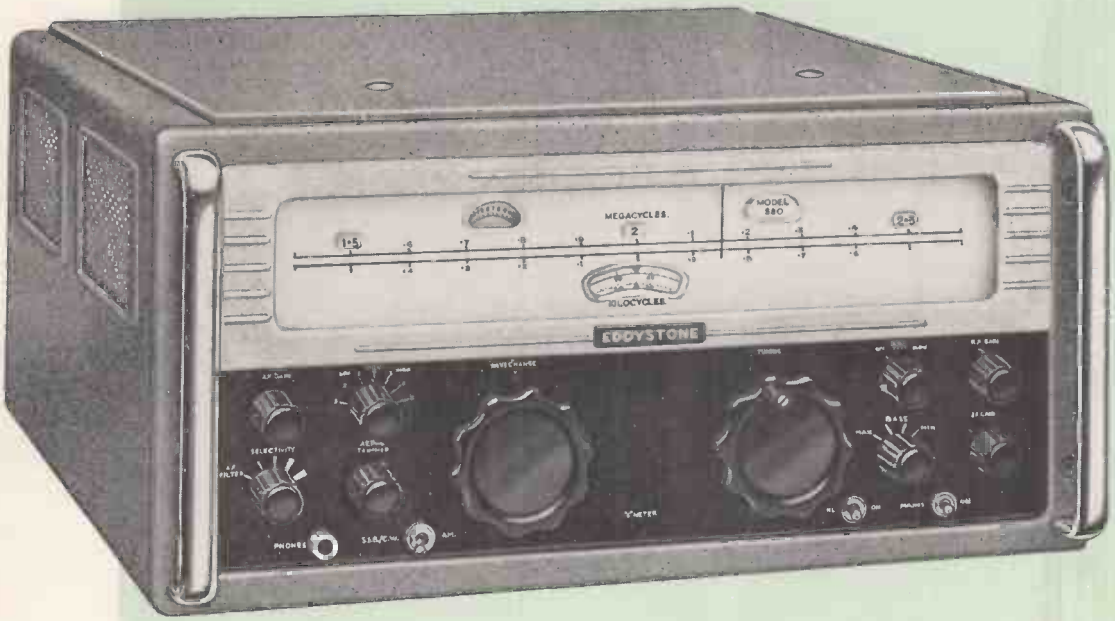

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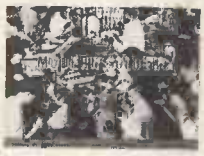

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